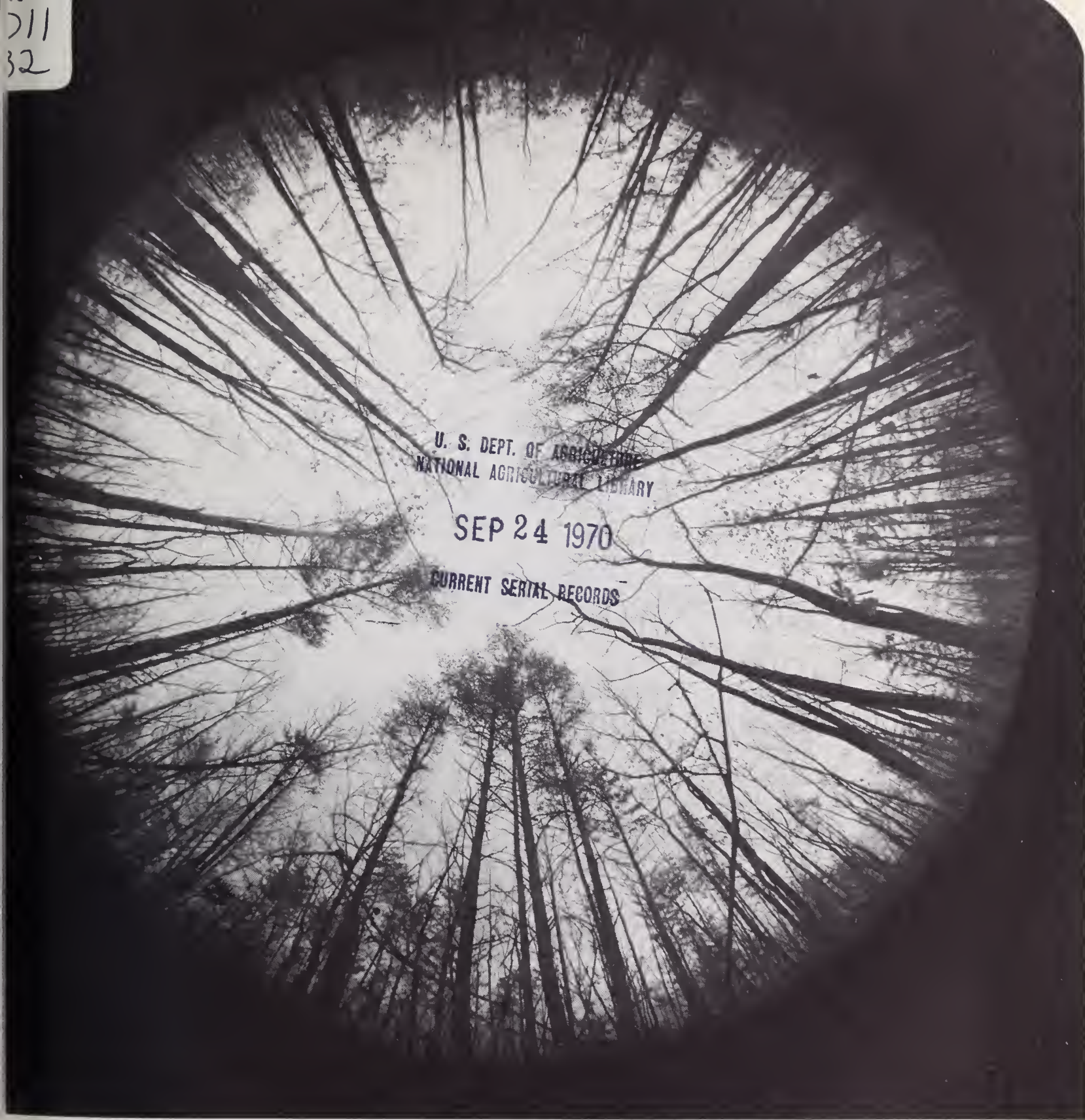


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# Forestry Research Progress in 1969

McIntire-Stennis Cooperative Forestry Research Program

COOPERATIVE STATE RESEARCH SERVICE U. S. DEPARTMENT OF AGRICULTURE



## Preface

The 1969 Annual Report of Forestry Research in the McIntire-Stennis program is similar in arrangement to the 1967 and 1968 reports. The projects active during 1969 are grouped in this report into nine chapters according to the Oxford System of Decimal Classification for Forestry. Subdivisions in each chapter are based on Research Problem Areas (RPA's) according to the descriptions in "A National Program of Research for Agriculture." For each RPA, about one-fifth of the active projects were selected to be featured in this report with written narrative and photographs or other illustrations. Another group of projects featured by narrative in this report were those that were terminated during 1969. Additional projects in each RPA are listed by location and by the principal investigator. At the end of each section is a list of publications resulting from the research projects cited. Projects selected to have supporting narratives in this report have not appeared in either the 1967 or the 1968 report, except for terminated projects. Narrative descriptions for selected projects were written by the project leaders in their 1969 progress reports and submitted to the Current Research Information System (CRIS).

The INTRODUCTION section features a description of CRIS, its history, purposes, and function. Introductory paragraphs for the chapters of this report describe in some detail the kind of research that is reasonably classified in that research problem area.

The printing costs of this report were borne by the Association of State College and University Forestry Research Organizations. Additional copies may be obtained by addressing a request to: Division of Information, Office of Management Services, U.S. Department of Agriculture, Washington, D.C. 20250.

Cover Photo: Hemispherical photographs were used in a study of the light climate within forests as an index to site parameters in Virginia. For further information see the report of Virginia Polytechnic Institute's project 636120, page 44.



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# FORESTRY RESEARCH PROGRESS IN 1969

## McIntire-Stennis Cooperative Forestry Research Program

### Introduction

The year 1969 was the sixth year during which the McIntire-Stennis Program provided funds for cooperative forestry research. At 60 cooperating universities, in all 50 states and in Puerto Rico, research was conducted by 521 forest scientists. Three hundred sixty six graduate students were actively engaged on one or more of the 507 projects funded through the McIntire-Stennis Act (P.L. 87-788). The combination of faculty scientists and one or more graduate students represents the usual approach to research in a university environment where research objectives are blended with the learning experience of graduate students and with teaching requirements of faculty scientists.

An additional Texas institution, Stephen F. Austin State University in Nacogdoches, was named by the Governor's Designee of Texas to participate in the McIntire-Stennis program. Thus, future research from this institution will be included in the Annual Report. The academic forestry program at Stephen F. Austin has been expanded recently to include graduate activity. The federal funds they will receive for forestry research will be accompanied by an allocation of State funds for research.

The year 1969 was not marked in the cooperating universities by the great expansion of faculty and in student enrollment shown in the preceding several years. This was due not only to budget restrictions at the national and State level, but also to a need on the part of the institutions to evaluate and reorganize their positions in forestry education and in research programming. This process was evident in the number of projects that were terminated during the year. The 100 terminations in 1969 are almost equal to all of the projects terminated from the beginning of the McIntire-Stennis program to the end of 1968. Thus, for the program as a whole, an important change has occurred, in that research programs are being structured to meet problems of critical importance at the State, regional, and national level. Landmarks such as these are detectable in the McIntire-Stennis program because of its relative newness; they will probably not be distinguishable in the future as the program becomes larger and more diversified in the kinds of research conducted.

The Current Research Information System (CRIS) makes it possible for cooperating research units to obtain a more realistic picture of the present state of research in forestry in the United States. It is for this reason that the CRIS classification of Research Problem Areas (RPA) is employed in this report and is the reason for the use of the introduction section to describe CRIS in greater detail with respect to its present and potential value as a planning tool for forestry research.

Although CRIS was formally organized in 1966, its beginnings can be traced to 1958 or 1959 when the Cooperative State Research Service (CSRS) (then a Division of Agricultural Research Service called Cooperative Experiment Station Service) recognized that its card cataloging system had become extremely unwieldy to



maintain information of current research in the States. A card sorting system was considered and then discarded although several commercial companies expressed their desire to solve the problem. After consultation with the Science Information Exchange (SIE), CSRS contracted three commercial computer service organizations to study all phases of a research record system and to recommend how, if feasible, such a system could be developed.

The Director of Science and Education for USDA became aware of the CSRS interest in this matter and determined that such a system might have application, not only in cooperative State research, but also to the entire research program in the Department of Agriculture. A committee was established to study the matter and, after almost a year, the committee reported that in spite of a number of problems, the Department should move ahead in cooperation with the State agricultural experiment stations to develop a computer record keeping system for all agriculture research. CRIS was organized in 1966 and made a part of the office of the Director of Science and Education. A contract was let to a commercial computer company to design the complete system.

CRIS was designed to satisfy two specific objectives: (1) Develop an information system to improve communications among scientists concerning ongoing research, and (2) develop an information system to provide more effective management information on the total research program of the State stations and of USDA. CRIS is supported solely by appropriations made to USDA and administered through the Office of Science and Education. Scientific and management information is available from CRIS on all the research work units or research projects from all agencies in the Department of Agriculture that conduct research. The research work unit as used in the Department of Agriculture research agencies is not the same as the "project" that emanates from the State Agricultural Experiment Station. The research work unit may cover the research for as few as one scientist to as many as 15 scientists on one CRIS report. As a result, descriptions of research work units are frequently very broad in the CRIS system and cannot be compared to those for more definitive projects that are submitted by the States.

A set of five forms was developed by CRIS to put information into the system and to obtain information retrieval. The first, form AD-416, identifies the project, the performing organization, and the project leader, as well as information on the type of funding that supports the project. In addition, there is space devoted to a concise statement of the research objectives and of the approaches that are contemplated. An important portion of this form is the space devoted to key words. All forestry research should have "forestry" as one of the key words; this is of great assistance in retrieval of forestry projects from the CRIS system. Form AD-417 contains the coding to describe a research project by its broad objectives, the commodity being researched, the area of scientific expertise involved, and the classification codes for research objectives according to the Planning, Programming, Budgeting (PPB) System. There are also special classification codes for areas of particular importance such as pollution, tobacco health related, and nuclear radiation related. These are the two forms which are submitted to record the approval of a new research project being introduced into CRIS.

For as long as a research project or research work unit is active, two additional forms are submitted to CRIS on an annual basis. Form AD-419 is a financial statement that describes the amount and source of money spent on a project during a fiscal year and the estimated expenditures for the coming fiscal year. In addition, the amount of scientist man years devoted to the research is given for the prior year and estimated for the following year. An annual progress report for the research is submitted to CRIS on Form AD-421. This contains space to report on how the research has progressed during the previous year and additional space show what publications have resulted from this research. There is also a provision for inserting additional works into the key word bank or to delete some words if it seems necessary. The same form is used when a project is to be terminated by providing the same kind of information as on a progress report but to add the termination information and the date of termination to show that the project is no longer active or funded. The last form, AD-427, is designed to submit to obtain retrieval of information stored in CRIS. Since the system contains so many projects, it is necessary to be as complete as possible in filling out this form to be certain that the printout requested will provide all the information desired.

A few comments about the nature of the Research Problem Area classifications and content may prove useful to those unfamiliar with this system. Classification of research projects into problem areas is sometimes a difficult task due to multiple objectives. Frequently, projects are equally divided between two RPA's and could therefore, be listed in two places in this report. An editorial decision as to listing may thus result in what appears to be a misclassification. This problem is accentuated by the occasional project in which the title is not descriptive of the research.

Many of the RPA's are quite inclusive, covering all areas of research which contribute to the objectives stated in the problem area outline. An example of this principle is demonstrated in RPA 111, Biology, Culture, and Management of Forests and Timber-Related Crops. Progress reports from physiology, ecology, soils, and other rather basic biological research useful in timber management will be found in this classification. Some of the projects in RPA 111 are found in Chapter I due to the fact that the research is biological. A second group is presented in Chapter 2, Silviculture, because it deals with various treatments and techniques for timber management. A third distinct group of projects from RPA 111 are those associated with research on measurements of growth, yield, and quality of timber. These are located in Chapter 5, Mensuration. Other RPA's, although conceived on the same integrative idea, are less inclusive of subject areas and are located completely in one chapter. For example, Genetics and Breeding of Forest Trees, RPA 301 is located in Chapter I with the other biological research.



## Chapter I

# FACTORS OF THE ENVIRONMENT, BIOLOGY

Organization of the 1969 McIntire-Stennis annual report will combine some of the usefulness of the Oxford System of Decimal Classification for Forestry, which is used internationally, with the Research Problem Areas (RPA's) used in the Current Research Information System (CRIS) for the administration of the research program of the U.S. Department of Agriculture. These two systems serve different purposes in that the Oxford System refers to subject-matter, what the research is concerned with; whereas the RPA's refer to goals and objectives of the National Agricultural Program - why the research is important. The individual entries tell who is doing the research and where it is done. Progress reports for 1969, as submitted to CRIS, have been randomly selected to illustrate how some of the work was done and what was gained from the research.

The heading of Chapter I indicates a dual, or interrelated, subject matter dealing with environment and biology. There is a great need for a better knowledge of the relationships between environment and the growth of forests. All factors of the environment are related directly or indirectly to the forest, resulting in complex forest-environment relationships which will never be perfectly understood. Foresters need to know enough about the environment to utilize it to provide goods and services for the present needs of mankind, and at the same time to correct previous mistakes while providing for future generations. Following are reports describing some of the current research intended to acquire that essential knowledge.

### APPRAISAL OF SOIL RESOURCES

#### Research Problem Area 101

Agricultural agencies make appraisals of the nation's soil resources through soil classification and mapping the classified soil types. Research in support of soil mapping is concerned with identifying the parameters to be measured including the correlation of soil map information with the use to be made of the data (e.g., crop production housing developments, zoning), and

the development of effective and economic ways of reporting the results.

In recent years the use of these findings has extended far beyond that made by farmers and ranchers. For example, sanitarians and home builders are using the information for judging the capacity of soils to absorb septic tank effluent; architects and developers use the information for site evaluation and foundation design; urban planners and other public officials use soil surveys for both general and operational



planning of land use in rapidly expanding areas. Soil surveys can also be used to show soil characteristics such as susceptibility to frost heave or slippage, frost heave, depth to water table, depth to rock or other impermeable barriers, bearing strength, flood hazard, and soil erosion potential which affect suitability of a site for specific uses.

#### **CONNECTICUT - NEW HAVEN, 411**

##### **Phosphorous in lake sediments.**

**R. D. HARTER, and C. R. FRINK**

The sediments of two recent man-made reservoirs, both considered highly eutrophic, were compared with those of a third moderately eutrophic lake created naturally about 10,000 years ago. The P content of the sediments was found to increase dramatically as P concentration increased in the incoming water, confirming predictions from previous laboratory studies of P sorption by sediments. Moreover, the distribution of P amongst the various inorganic fractions was strikingly similar to laboratory predictions: the adsorption maximum for  $\text{NH}_4\text{F}$ -extractable P was estimated to be 350-450  $\mu\text{g}$  P/g. sediment, and values observed in the reservoirs were 350-500  $\mu\text{g}$  P/g. In laboratory studies, NaOH-extractable P increased sharply as P was added, presumably due to precipitation of iron phosphates. In the man-made reservoirs, NaOH-extractable P was 10-fold greater than in the natural lake, although the incoming P concentration was only about twice as great.

The implications of these observations of new lakes is not encouraging. The most recent impoundment, only 13 years old, was found to contain twice the sediment P concentration as the natural lake after 10,000 years. "Galloping eutrophication" is apparently more than a catchy phrase.

#### **UNIVERSITY OF WASHINGTON, 17**

##### **Pedological investigation of forest soils.**

**F. C. UGOLINI**

A review of the literature concerning forest-prairie transitions has been made. Sediment cores from two lakes in the area of the forest-prairie transition have been taken and will be used for a pollen analysis of the vegetational history of the region.

Several prairie-forest transitions on glacial outwash materials were selected for study. Plant opal analysis

of surface soil samples indicates that soil morphological differences across the transects are closely related to vegetational history. Total carbon in the surface 10 cm of soil appears to show no trend with respect to vegetative cover. However, the ratio of the sodium hydroxide-sodium pyrophosphate extractable carbon to the total carbon decreases as one moves across the transect from prairie to forest, indicating that a greater percentage of the carbon in the forest soil is perhaps in the form of charcoal or unhumified plant residues. The ratio of soil humic acid/to fulvic acid from the A1 horizon are found to decrease along the transect from prairie to forest. This decrease is thought to be related to the character of the organic litter and the moisture relations caused by the ground cover vegetation.

### **ADDITIONAL PROJECTS**

#### **UNIVERSITY OF HAWAII, 139**

##### **Fertilization and culture of Hawaii tree crops.**

**Y. W. TAMIMI**

#### **UNIVERSITY OF HAWAII, 140**

##### **Forest floors and soils in some introduced and indigenous forests of Hawaii.**

**L. D. SWINDALE and Y. W. TAMIMI**

### **PUBLICATIONS**

#### **FRINK, C. R.**

Water pollution potential estimated from farm nutrient budgets. *Agron. J.* 61: 550-553. 1969.

#### **FRINK, C. R.**

Farm nutrient budgets and water pollution. *Frontiers Plant Science*, 21(2): 4-5. 1969.

#### **FRINK, C. R.**

Chemical and mineralogical characteristics of eutrophic lake sediments. *Soil Sci. Soc. Amer. Proc.* 33: 369-372. 1969.

#### **FRINK, C. R.**

Fractionation of phosphorus in lake sediments: analytical evaluation. *Soil Sci. Soc. Amer. Proc.* 33: 326-328. 1969.

#### **HARTER, R. D.**

Phosphorus adsorption sites in soils. *Soil Sci. Soc. Amer. Proc.* 33: 630-631. 1969.

## SOIL, PLANT, WATER, NUTRIENT RELATIONSHIPS

### Research Problem Area 102

This problem area is concerned with the chemical and physical nature of interrelationships among soils, plants, water and nutrients. The objective is to maintain or restore the inherent production capability of soils.

#### UNIVERSITY OF ARIZONA, 636

**Nitrogen and carbon balances in forest and range ecosystems in Arizona.** J. O. KLEMMEDSON

A study of nitrogen and carbon balances in ponderosa pine forests of central Arizona is yielding information on distribution of these elements in various forest ecosystems from small grassy parks with scattered mature overstory to dense doghair pine stands with herbaceous species absent. Spacial distribution of nitrogen appears to be most variable in herbaceous, litter, and soil surface horizons of grassy parks, decreasing in variability as the pine overstory thickens and grass disappears.

Studies are progressing to measure the impact of thinning, pulpwood harvesting, and followup slash burning on the nitrogen regime of dense sapling and pole stands. Post-burn sampling of slash piles has been conducted at two dates and will be continued to measure fate of nitrogen in the slash. Sampling will be continued annually to measure effect of thinning and burning on redistribution of residual nitrogen to herbage and to timber increment.

Field sampling was initiated on a study to determine the amount and distribution of N and C as a function of parent material. Dense sapling and pole stands of ponderosa pine and open grassy parks were sampled in this study on limestone, rhyolite, basalt and andesite parent materials.

#### UNIVERSITY OF KENTUCKY, 194

**Cation and anion uptake by plant roots.**

A. J. HIATT

Three wheat varieties which demonstrated different tolerances for soil acidity showed varietal differences in their ability to alter the pH of the medium in which they were grown. The basic physiological mechanism involved in solution pH alterations by

plants was investigated. The three wheat varieties were grown under carefully controlled conditions in solutions of  $\text{Ca}(\text{NO}_3)_2$  and  $\text{KNO}_3$ . Absorption of K,  $\text{NO}_3$ , and Ca were determined and  $\text{H}^+$  ion transfer between the plants and the solution was determined. It was found that the difference between an anion uptake and cation uptake ( $\text{NO}_3 - \text{K}^+ + \text{C}_a^{2+}$ ) was stoichiometrically balanced by changes in  $\text{H}^+$ . All  $\text{H}^+$  change in the growth medium was accounted for by differences between  $\text{NO}_3$  uptake and  $\text{K}^+ + \text{C}_a^{2+}$  uptake. Varietal differences in pH changes were accounted for by ion uptake imbalances. Tolerance to soil acidity appeared to be related to efficiency of utilization of  $\text{NO}_3$  nitrogen when solution contained only  $\text{NO}_3 - \text{N}$ . Varietal differences in pH effects were increased when 1-2% of the total nitrogen was supplied as  $\text{NH}_4 - \text{N}$ . In general acid tolerant varieties appeared to more efficiently utilize  $\text{NO}_3 - \text{N}$  and less efficiently use  $\text{NH}_4 - \text{N}$  than acid sensitive varieties. Available evidence suggests that varietal and species differences in alteration of the pH of the growth medium is due largely to differences in nitrogen metabolism. This research may lead to improved means of selection of plant species and varieties to grow on acid soils and to a better understanding of nutritional requirements of such plants.

#### PENNSYLVANIA STATE UNIVERSITY, 1745

**Revegetation of highly adverse sites created by coal mining.**

R. J. HUTNIK, F. Y. BORDEN  
and W. W. WARD

During the summer of 1969, the environment of a deep-mine refuse bank was studied. Soil moisture and temperature were measured on southeast, south, west, northwest, and horizontal aspects. (Figure 1) Among the initial results are: (1) although the refuse dried out rapidly near the surface, it remained moist throughout the summer at a depth of nine inches; (2) the surface reached a maximum of 160 F, and on several occasions, it remained above 140 F for more than four hours on all aspects except the northwest; (3) the temperature 1/3 inch below the surface reached a maximum of 131 F, and stayed above 122 F for 4-1/2 hours; (4) temperature gradients as steep as 40 F between the surface and 1/3 inch below, and 48 F between the surface and 1/3 inch above were measured.





Figure 1. Using infra red thermometer to compare temperatures of bare and plastic-covered spoils.

A study was made of the chemical quality of percolate through mine spoil after applications of sewage sludge and weekly application of sewage effluent. Pyrite-bearing spoil was used with a 4.1 pH. Renovation of the solution was satisfactory for Ca, P and LAS. S concentrations decreased to 50 ppm S in the 38th week. Concentrations of Fe were low except for sludge treatments where they had decreased to 30 ppm after thirty weeks. K concentrations remained above effluent concentrations for sludge treatments throughout the study. The pH of the percolates remained about 4 for all treatments except for some sludge treatments where it increased in 30 weeks to about 6.5. Ammonia was generated in some sludge treatments during the first 10-20 weeks. Percolate from some sludge treatments was discolored and had an offensive odor.

## ADDITIONAL PROJECTS

### UNIVERSITY OF ARKANSAS, 610

Use alternatives on forest lands of the Ozark Upland Region of North Arkansas. F. M. MEADE

### UNIVERSITY OF FLORIDA, 1250

Water control for forest production.

W. L. PRITCHETT and R. E. CHOATE

### UNIVERSITY OF KENTUCKY, 199

Edaphologically important physical and chemical properties of major forest soils. R. L. BLEVINS

### LOUISIANA STATE UNIVERSITY, 1276

Rooting depth of mature Southern pine trees as limited by soil characteristics. N. E. LINNARTZ



UNIVERSITY OF MAINE, 5008

Fertilization of spruce-fir sites. C. E. SCHOMAKER

UNIVERSITY OF MONTANA, 1101

Genesis of a brown podzolic soil. T. J. NIMLOS

NEW YORK - CORNELL UNIVERSITY, 901

Effects of ectotropic mycorrhizae on tree growth.  
E. L. STONE

UNIVERSITY OF WASHINGTON, 12

Influence of fire on forest soils. D. W. COLE

## PUBLICATIONS

BEYER, L. E.

Acid and aluminum toxicity as related to strip-mine spoil banks in western Pennsylvania. M.S. thesis, The Penn. State Univ. 1969.

BEYER, L. E. and R. J. HUTNIK.

Chemical properties of toxic strip-mine spoil banks in Pennsylvania. Proceedings, Symposium on pollution control in fuel combustion, processing and mining. Am. Chemical Soc. Mtg. Division of Fuel Chem. 13(2): 120-123. 1969.

DODGE, C. S.

Relationship of pH change of growth media to imbalances in ion absorption by three varieties of wheat. M.S. thesis. Univ. of Kentucky.

McCORMICK, L. H.

The chemical quality of percolate resulting from the application of sewage sludge and effluent to acid strip mine spoils. M.S. thesis, The Penn. State Univ. 1969.

## CONSERVATION AND EFFICIENT USE OF WATER

### Research Problem Area 105

Virtually all of the Nation's water supply arrives as precipitation upon the land. Seventy percent of this supply is lost through evaporation and transpiration. The remaining 30 percent is subject to increasing competition between agricultural, industrial and domestic users. Increased efficiency in collecting, storing, conveying, using and reusing available supplies becomes essential.

One example of a reclaimable supply is on irrigated farms where about 76 million acre feet of water are lost by evaporation, seepage, wasteful runoff during irrigation, and use by non-beneficial plants.

UNIVERSITY OF RHODE ISLAND, 954

Evapotranspiration losses as related to site and vegetation differences. J. H. BROWN

A major objective of this project is to determine the range of evapotranspiration losses from typical Rhode Island forest stands and attempt to relate these losses to vegetation types taking into consideration topographic and soil differences. Losses were computed for 1966, 1967 & 1968 and were found to range from 18 inches to 26 inches per growing season. Relationships between losses and aspect and species are indicated but sampling is still not sufficient so as to warrant definite conclusions. More thorough sampling of forest stands has since been accomplished. During the 1969 growing season soil moisture content was monitored weekly from 36 neutron-probe access tubes located in 6 forest stands. Sampling, for the 1969 growing season, was concentrated in mixed-oak stands and white pine stands. Mixed-oak stands representing a north slope, a south slope and level location were sampled; each contained a total of 9 access tubes. In addition, 3 white pine stands on level locations were sampled; each contained a total of 3 access tubes. From this data finer estimates of evaporation losses based upon changes in soil moisture content from field capacity will be obtained.

## EROSION CONTROL AND WATERSHED MANAGEMENT

### Research Problem Area 107

Nearly 12,000 agricultural and forested watersheds in the country are in the size category commonly encompassed in developments under the Watershed Protection and Flood Prevention Act, the Small Reclamation Projects Act, and similar programs. These watersheds include the cropland of the U.S. as well as the range and forest lands. Many of these watersheds need one or more of the following flood prevention systems: sediment control, wind and water erosion control, and improved management for water yield and quality.



Erosion control is needed to protect the productive capacity of the land. Sediment control is needed to prevent unwanted deposition of eroded material in reservoirs, harbors, stream channels, streets and highways, or on floodplain lands. Sediment in streams damages recreational values and must be removed from domestic and industrial water supplies.

#### UNIVERSITY OF MASSACHUSETTS, 2

Evapotranspiration, run-off, storage and drainage characteristics of forest soils. D. L. MADER

Major effort for this year has been in the Cadwell Creek Experimental Watershed of the Quabbin Reservoir. The effects of a heavy harvest cutting, a riparian zone treatment, and in addition, some areas of low density management, on stream flow are being evaluated. An intensive study of soil moisture gradients in the riparian zone has been initiated. Effects of

changes in cover density on snow and frost will be measured during the winter of 1969-70. A study of soil moisture regimes in forest openings is being initiated on Cadwell Forest.

The data for several years of measurement of soil moisture regimes in various stands and soil types has been reduced to graphical form and is being related to moisture use and growth by forest stands.

#### PENNSYLVANIA STATE UNIVERSITY, 1495

Influence of timber harvesting methods on small watersheds. W. E. SOPPER, R. E. MELTON,

and P. W. FLETCHER

Partial removal and herbiciding of the vegetative cover on a forested experimental watershed in Central Pennsylvania resulted in significant increases in water yield. (Figure 2) During the period January to April,



Figure 2. Partial clearcut of 106-acre watershed to determine effect on water quality and quantity.



21.3 acres of the lower one-third of a 106-acre watershed were clearcut. Treatment resulted in an increase of 2.7 area-inches in annual water yield during the first year (May 1, 1967 to April 30, 1968), following logging. Most of this increase (2.3 area-inches) occurred during the growing season, particularly July, August, and September and represents an increase of approximately 7 million gallons of water during the time when the demand for water is greatest and the supply lowest. The partial clear-cutting had a variable effect on instantaneous peak flows above 10 csm. Significant increases in maximum peaks of approximately 50 percent were observed for 8 out of 20 storms. All of these occurred during the growing season and did not represent any flood threat. Treatment also reduced the number of days of low flows. The number of days that flows were below 0.1 csm was decreased from 158 days to 65 days. Careful logging caused little disturbance of the soil surface and, hence, had only a minor effect on water quality. Only 8 of a total of 23 water samples collected during logging had a turbidity which exceeded 25 ppm. Maximum storm turbidity measured during logging was 550 pps. Water temperatures were slightly increased. Average monthly maximum water temperatures during June, July, and August increased an average of 6°F (62°F to 68°F). In general, the increase in turbidity and water temperature was not detrimental to the quality of the water or any aquatic life.

### Additional Projects

#### UNIVERSITY OF ARIZONA, 631

Snow water yield from a conifer forest.

D. B. THORUD

#### COLORADO STATE UNIVERSITY, 312

Land use and water quality on a forested mountain watershed.

J. R. MEIMAN

#### COLORADO STATE UNIVERSITY, 321

Water yields from shallow mountain soils in relation to forest cover.

E. W. MOGREN

#### CONNECTICUT - NEW HAVEN, 408

Conserving soil moisture with a stomata-closing chemical.

P. E. WAGGONER

#### CONNECTICUT - NEW HAVEN, 415

Waste water renovation potential of forest soils.

D. E. HILL and C. R. FRINK

#### UTAH STATE UNIVERSITY, 641

Management of aspen and water yields.

J. D. SCHULTZ

#### UTAH STATE UNIVERSITY, 733

Data reduction methods for streamflow from small wildland watersheds.

G. E. HART

#### UTAH STATE UNIVERSITY, 777

Water balances in intermountain stands of Engelmann spruce-subalpine fir.

G. E. HART

#### UTAH STATE UNIVERSITY, 780

Root distribution and soil moisture depletion in three clones of gambel oak.

J. D. SCHULTZ

#### UNIVERSITY OF WASHINGTON, 20

Quantity measurements of snow-melt as related to run-off.

D. D. WOOLDRIDGE and S. P. GESSEL

#### WASHINGTON STATE UNIVERSITY, 1913

Watershed disturbance by tractor skidding.

D. R. SATTERLUND

#### WASHINGTON STATE UNIVERSITY, 1925

Ecologic characteristics of elk sedge for erosion control.

B. F. ROCHE, JR.

#### WASHINGTON STATE UNIVERSITY, 1969

Systems analysis of a forested watershed.

W. R. BUTCHER

### PUBLICATIONS

#### LYNCH, J. A.

Changes in streamflow following partial clearcutting on a forested watershed. M.S. Thesis. The Penn. State Univ. 1969.

#### LYNCH, J. A. and W. E. SOPPER.

Changes in streamflow following partial clearcutting on a forested watershed. Research Briefs 4(1): 8-11. Sch. of For. Res., The Penn. State Univ. 1969.



**SHIELDS, R. R and W. E. SOPPER.**

An application of surface geophysical techniques to the study of watershed hydrology. *Water Resources Bulletin* 5(3): 37-49. 1969.

**SOPPER, W. E.**

Research in forest hydrology. *Proc. III Forestry Symposium of Minas Gerais on Research and the Forest Industries. Rural University of Minas Gerais, Vicosá, Brazil, p. 17-29. 1969.*

## **ADAPTATIONS TO WEATHER AND WEATHER MODIFICATION**

### **Research Problem Area 109**

The future holds many possibilities for changes in weather and climate ranging from dramatic major changes to micro-environmental changes around plants and animals. Research in agriculture has three tasks: (1) characterize existing climatic patterns and propose more effective ways of adjusting to these patterns, (2) specify modifications that are clearly desirable to farm and forest, and (3) learn how modifications proposed by others will affect agriculture or natural ecology.

**UNIVERSITY OF MISSOURI, 522**

**Energy and water balance of forest and range sites.**

**G. S. COX**

The vertical distribution of carbon dioxide was measured at different locations within a white oak stand. At each location samples were taken at heights of 10, 20, 30, 40, 50 and 60 feet above the ground. Air was drawn through plastic tubing from each sampling intake to an infrared gas analyzer where the carbon dioxide content was determined. Samples were taken at five-minute intervals for a period of 10 days at six different times of the year—summer, two periods in the fall, winter, and two periods in the spring. The two periods in the fall encompassed the cessation of photosynthetic activity by the leaves, while the spring periods covered the time of leaf development. While field data are still being analyzed, preliminary analyses indicate that the CO<sub>2</sub> concentration for each of the six sampling periods was significantly different from that of the other five. Average diurnal CO<sub>2</sub> maxima and minima for the four seasons of the year are shown in the following summary—summer: 7AM-388 ppm, 5PM-333 ppm;

fall: 7AM-391 ppm, 5PM-358 ppm; winter: 6AM-382 ppm, 4PM-370 ppm; spring: 4AM-404 ppm, 4PM-363 ppm. These measurements indicate CO<sub>2</sub> concentration in the forest never drops to 300 ppm and is considerably above the values given for agricultural crops. This higher concentration may be a partial explanation for the relatively good growth of trees on sites of low productivity. Analyses are continuing to determine the influence of wind, temperature and humidity on CO<sub>2</sub> profiles, to ascertain the inward flux of atmospheric CO<sub>2</sub> above the canopy into the stand, and to determine the CO<sub>2</sub> contributed by the forest floor.

## **CULTURE, AND MANAGEMENT OF FORESTS AND TIMBER-RELATED CROPS**

### **Research Problem Area 111**

Culture and management are directed at producing adequate supplies at reasonable cost, by methods that harmonize with other forest uses. For the 40 important commercial timber types in the United States, it is necessary to develop techniques for intensive culture on the most accessible and productive sites; and methods for combining timber culture with other uses on the remaining sites. The major job is to find out how to convert wild forests to managed forests of better species, higher quality, and faster growth in the shortest time and at least cost. Each type, including Christmas trees, has distinctive silvicultural characteristics. Research devises improved cultural techniques for the more than 130 commercial timber species, and better methods for forecasting growth and quality changes in relation to management practices, thus providing the basis for selection of economic alternatives.

**UNIVERSITY OF ALASKA, 0504**

**Nutrient cycles in selected interiors of Alaska forest types.**

**K. VAN CLEVE**

As part of the larger study of Nutrient Cycles in Selected Interior Alaskan Forest Types a survey has been completed of chemical properties of the forest floor in upland stands of paper birch and quaking aspen. Aspen forest floors were found to have a greater total mass of all elements examined (N, P, K, Ca, Mg, Mn, Zn, Fe) with the exception of Mn. Higher base status, lower exchange acidity and greater cation exchange capacity were encountered in aspen



than in birch forest floors. A study of forest floor respiration rates in adjacent uplands stands of 50 year old birch and aspen showed that there is no significant difference in forest floor respiration between the two stands. This relationship indicates that the chemical properties of the organic matter and the associated microbial populations are not sufficiently different between these stands to result in marked differences in organic matter decomposition. In pilot studies, additions of fertilizer ( $\text{NH}_4\text{NO}_3$ , KCl and treble superphosphate) to young, intermediate and mature stands of aspen and birch produced increases in diameter growth in all but mature aspen (120 years old). The most dramatic increases in diameter over the period 1967 to 1969 were in a 10 year old aspen stand. Diameter increment for 1968 and 1969 was 2.6 and 5.9 times greater for the fertilized trees than control trees. Height increment was 9.2 times greater for fertilized than control trees in 1969. In order to perfect techniques for measurement of nutrient status and biomass in local forest types a study was conducted of the accumulation of nitrogen in stands of *Alnus incana* growing on the Tanana River flood plain. Samples of above ground and root biomass and soil were obtained. Approximately 2300 Kg/ha, 3100 Kg/ha and 3500 Kg/ha nitrogen is accumulated in the soil-plant system in 5, 15 and 20 year old stands of alder respectively.

#### UNIVERSITY OF GEORGIA, 14

##### Physiology and biosynthesis of oleoresin in naval stores pines. C. L. BROWN

The applied aspects of this study were completed in September of 1969. Numerous extraction techniques have been studied over a three-year period in an attempt to lower the cost of gum extraction. Emphasis was placed on short-term (June-August) extraction periods to take advantage of high seasonal gum yields during the summer months. One technique utilizing three standard, non-overlapping, faces separated vertically by 30 or more inches on different sides of the tree holds some promise for future automated methods of gum production. Although no single extraction method has been devised to lower significantly the current cost of gum production, these applied studies have provided valuable information on the general physiology of gum production, transport, and mobilization.

Basic studies on oleoresin biogenesis have continued utilizing the incorporation of  $\text{C}^{14}\text{O}_2$  and mevalonic

acid- $\text{C}^{14}$  in longleaf and slash pine seedlings. Labeling experiments with  $\text{C}^{14}\text{O}_2$  and mevalonic acid- $\text{C}^{14}\text{O}_2$  show a much higher incorporation of label (ca. 15 fold) in the cortical oleoresin than in the xylem resin at the end of seven days. Difference in monoterpene and resin acid composition have been found in various tissues of both longleaf and slash pines and these differences are now being studied in relation to differences in rates of incorporation of labeled precursors. The incorporation of labeled mevalonic acid was good in the monoterpenes and carotenoids, but its incorporation in resin acids was very low. Current emphasis is being placed on intercellular sites of oleoresin synthesis and the major pathways of production of these commercially important compounds. When more is known about these aspects of synthesis it may be possible to stimulate resin production chemically by altering the levels of one or more intermediates in living trees.

#### IOWA STATE UNIVERSITY, 1582

##### Physiology, genetic, and environmental factors of two forest tree species. J. R. McBRIDE

In a controlled-environment (growth chamber, Figure 3) study of the effects of soil moisture, soil texture, temperature, and light intensity on  $\text{CO}_2$  exchange of Scotch pine seedlings (Bulgarian, Finnish, Polish, and Czechoslovakian seed source) the rate of dark respiration increased with temperature and, in experiments with low light intensities, with preceding light intensities. An increase in light intensity decreased in  $\text{CO}_2$  compensation point, but an increase in temperature increased the  $\text{CO}_2$  compensation point. The data collection phase of the experiments involving soil moisture and texture is still in progress.

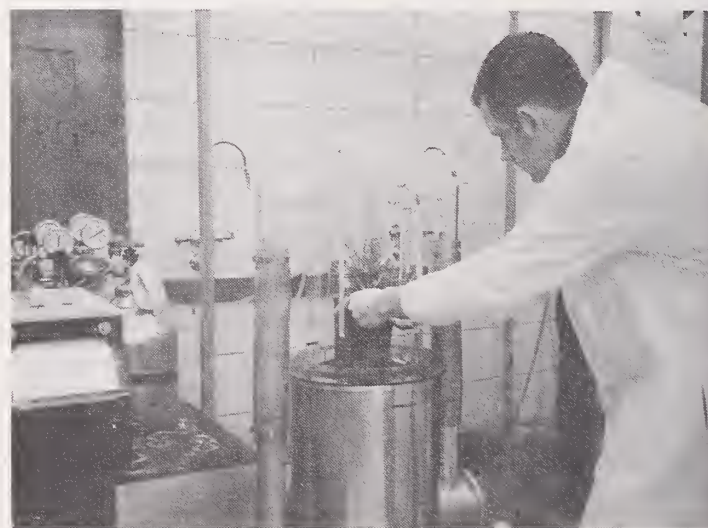


Figure 3. Scotch pine seedling being placed in photosynthesis chamber.



In conjunction with the soil moisture and texture experiment the seedling parts will be analyzed for total nitrogen and nitrate nitrogen content. The analysis should provide a better understanding of the uptake and subsequent distribution of nitrogen as it is related to variation in soil moisture and texture. The effects of three forms of nitrogen fertilizer (nitrate, urea, and ammonium) on growth are being studied in a separate controlled environment (greenhouse) experiment. This study involves two Scotch pine seed sources (Bulgarian and Latvian).

#### UNIVERSITY OF MASSACHUSETTS, 9

Maple tree root initiation, development, and geotrophic response. B. F. WILSON

Many of the woody branches of a tree root system were caused by injury to the parent root tip. Experimental injuries produce points of branching that are morphologically and anatomically similar to points of branching in excavated root systems. The type of branching, and the anatomy associated with it, is a function of the type of injury. Decapitations of 2 mm or less produce V-shaped branching and greater decapitations produce some variation of a U-shaped branching. Many of the branches in seedlings, or that develop into "sinker" roots near the stem, do not appear to be associated with injuries. In these cases lateral root tips enlarge radially as the root elongates until the tip reaches the diameter of most branch root tips.

#### UNIVERSITY OF MASSACHUSETTS, 10

The role of mechanical stress in cambial activity of trees. B. F. WILSON

Towers have been built around eight 30-foot white pine trees in a heavily thinned stand and guyed so they will not sway. This is the first step in a long-term experiment.

A project for calculating the stiffness and stress involved in the righting of a leaning white pine leader by compression wood formation has been nearly completed.

#### UNIVERSITY OF MICHIGAN, 1

Techniques for use of  $C^{14}O_2$  to tag current photosynthate in studies of phloem transport in forest trees. R. ZAHNER

C-14-photosynthate was produced in red pine (*Pinus resinosa* Ait.) in May, July, and October. Subsequent harvests of trees were made in July, October, and January (for May exposures), in October, January, and May (for July exposures), and in January, May, and July (for October exposures). Seasonal pathways of photosynthate were traced in old leaves, new shoots, stems, and roots, in cell wall fractions, and in lipids, sugars, starch and proteins.

Pathways of C-14 photo-assimilated at different times of the year were sharply defined; for example, little mixing of C-14 assimilated in May was found with C-14 assimilated in either July or October. In May a large proportion of C-14 was channeled into cell walls of new shoots and needles, with very little entering roots, while in October C-14 transported to the roots was utilized as both cell walls in fall root growth and overwintering storage. Fats were found more important than starch as reserves. Project terminated June 30, 1969.

#### UNIVERSITY OF MINNESOTA, 19-16

Environmental factors related to the failure of red pine reproduction. BRUCE A. BROWN

After three growing seasons, shade levels up to 73 percent have not seriously affected survival of red pine seedlings (Figure 4). However, growth and development are markedly affected. Data have been collected to evaluate impact on root length, total height, annual height, needle length, stem thickness, and dry weight. Preliminary analyses indicate a direct relationship with light intensity.

The plots under natural stand conditions continue to have difficulty getting seedlings started (Figure 5). These problems are primarily related to seed predation. To overcome this problem modified seeding methods were used: sand mulch and pre-germinated seed. After one growing season, germination and survival are best on scarified areas under a heavy red pine canopy (Figure 6). After two growing seasons,





Three year-old red pine seedlings grown under full sunlight.



Three year-old red pine seedlings grown under heavy (73%) shade.

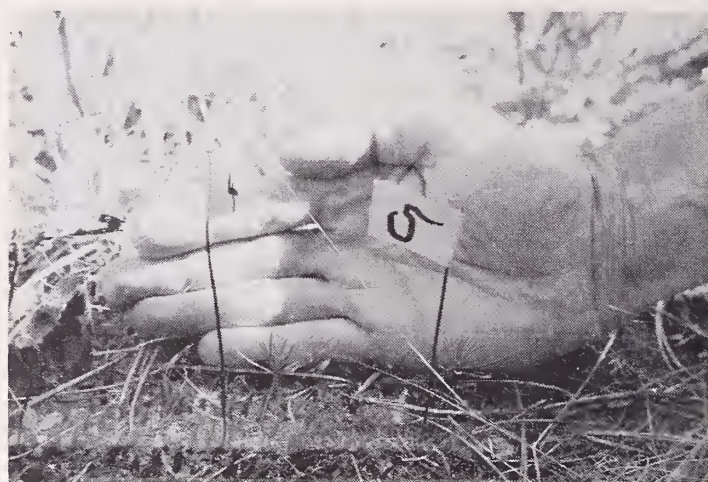
Figure 4



Figure 5. Study area for red pine regeneration. Plot enclosures represent various levels of shade and moisture conditions.



One year-old red pine seedlings under severe competition from herbaceous growth (big leaf aster) on burned-over site.



One year-old red pine seedling development unaffected by herbaceous competition on scarified site.

Figure 6

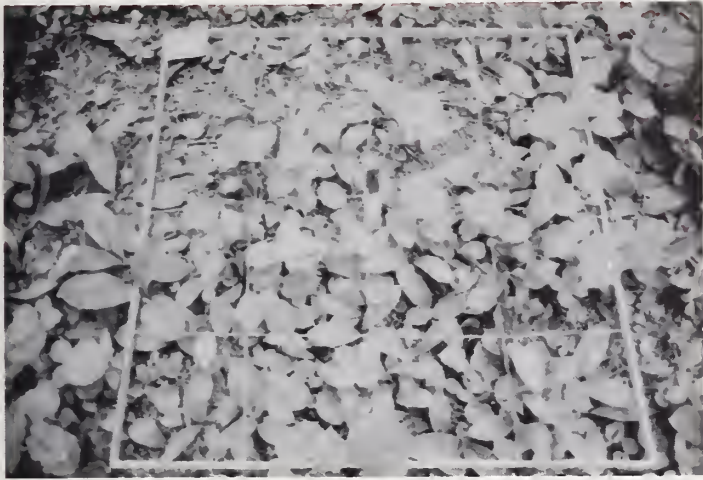
comparisons have been made of the regrowth of competing vegetation on scarified and burned plots (Figure 7). Burned plots at all shade levels had the most regrowth.

**NORTH CAROLINA STATE UNIVERSITY, 4013**  
**Taxonomy, distribution, and ecology of Carolina**  
**shagbark hickory.**

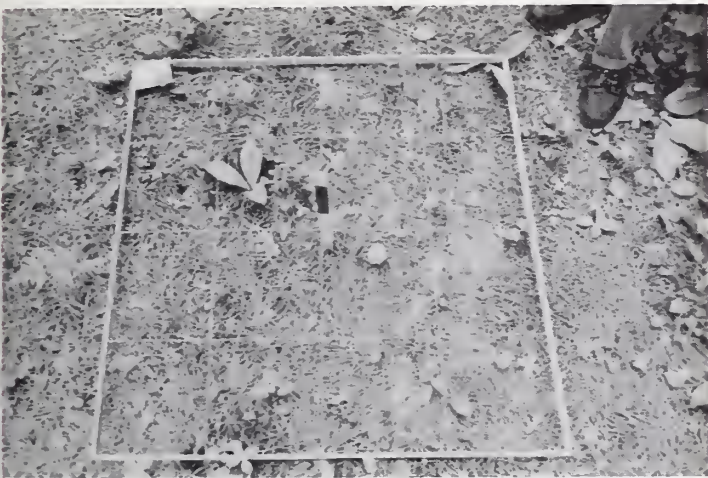
**A. W. COOPER and J. W. HARDIN**

An analysis of morphological variation between the two taxa and a numerical taxonomic analysis, based on 12 vegetative characters, suggest that the two taxa should be regarded as a single species, but are distinct subspecies. Size and shape of fruit was found to be





Herbaceous growth after two growing seasons on burned-over area under fully stocked, mature (120+ years) red pine stand.



Herbaceous growth after two growing seasons on scarified site under fully stocked, mature red pine stand.

Figure 7

quite variable throughout the sympatric range of the two taxa. Thus the ensemble of vegetative characters provided the more reliable way of distinguishing the two taxa. Size, shape, and color of terminal buds on twigs growing in full sunlight were the most reliable characters for field identification.

The two taxa occur on a wide variety of soils throughout their sympatric range. While Carolina shagbark does appear to show some preference for more basic soils (the observation of this fact in the field suggested this study), it also occurs on acid soils, especially along the flood plains of rivers.

A canonical correlation analysis of selected vegetative characters of individual trees and measurements characterizing soil samples collected from beneath the canopy of these same trees shows a strong correlation between vegetative characteristics by which the taxa

are distinguished and soil characteristics. An attempt to delimit the soil characteristics making a strong contribution to the high canonical correlation suggests that the content of soil calcium, magnesium or both, influence the occurrence of the taxa.

A doctoral dissertation based on this project is nearing completion.

#### UNIVERSITY OF NEVADA, 670

Evapotranspiration patterns of forest and brush vegetation on east slopes of the Sierra Nevadas.

C. M. SKAU and J. S. SWANT

Sapflow at 8 points within a young conifer has measured concurrently with leaf water potential, solar radiation, humidity and water table level measurements. Data reduction from this and previous experiments nears completion. Preliminary analysis is far enough along to indicate that the project can be terminated by June 1970. Results to date show that evapotranspiration from at least two brush forest species do not fully obey a linear relationship with solar radiation and humidity as predicted by theory even when adequate water is available. In one species (Jeffrey pine) there is some evidence that transpiration is being limited by a waxy plug rather than by guard cell closure, which may be helpful in the search for antitranspirants. An empirical equation that more nearly describes the actual transpiration rate is:

$$T = 1 + \frac{1}{[-a(R_n - R_o) + b(e_a - e_s)]}$$

where  $a$ ,  $b$  and  $R_o$  are constants;  $R_n$  is net radiation and  $e_a - e_s$  is the vapor pressure deficit.

#### OKLAHOMA STATE UNIVERSITY, 1332

Metabolism and movement of herbicides in woody plants.

E. BASLER, JR.

The phenoxy herbicides have been used for the control of broad-leaved woody plants. The degree of movement of these herbicides to critical sites in woody plants is a major factor in the variable efficiency experienced in the use of these herbicides. Studies on factors affecting movement of phenoxy herbicides have been continued. The dosage level affected the degree of movement of 2,4-D and 2,4,5-T after stem injection in bean plants. High dosages enhanced upward translocation of 2,4,5-T. Downward movement to the nutrient solution was more rapid for 2,4-D than 2,4,5-T. Nutrient levels



affected translocation rates. High nutrient calcium levels enhanced 2,4,5-T downward movement during the second day after calcium and 2,4,5-T treatment. Monovalent cations such as sodium or ammonium caused short lived enhancements of 2,4,5-T downward movement and the effect was larger when the cation was placed in the nutrient solution a few hours before 2,4,5-T treatment. Relative humidity affected movement. High humidity increased downward movement. Low humidity increased upward movement of 2,4,5-T especially in plants which had been grown in low humidities. Studies showed that applied gibberellin decreased the effectiveness of 2,4,5-T in persimmon. Field studies showed that anti-gibberelline such as CCC and phosphon enhanced the kill of persimmon by 2,4,5-T. It is anticipated that these studies will lead to herbicide usage practices where only one application of herbicide will provide adequate control and thus limit the amounts of herbicides being introduced into the environment and also lower the costs involved in control of undesirable woody plants.

#### **OREGON STATE UNIVERSITY, 646**

**An ecological framework for forest land management in Southwestern Oregon.**

**R. H. WARING**

Environment affects each species of forest plants differently, but the kinds of environmental factors are similar: moisture, temperature, chemical, light, and mechanical. This study in the dry Eastern Province of the Siskiyou Mountains in Southwestern Oregon showed that forest plant distribution was most closely correlated with gradients of moisture and temperature. (Figures 8 and 9) The other factors were significant at extremes. For example, where soils were derived from ultrabasic rocks, only plants with low nutritional requirements dominate the site. At higher elevations, mechanical stress from ice and snow may eliminate brittle-limbed species of trees.

Quantitative models are being developed for the distribution of several commercial tree species as related to plant moisture stress and temperature. The models will enable the forester to predict, to some extent, the response patterns of forest species to environmental changes caused by harvesting procedures. They will permit the forester to choose those logging methods that will minimize deleterious effects of the harvest. In addition, the models will also assist him in achieving an effective regeneration program.



Figure 8. Thermographs were installed on 25 plots throughout the study area to continuously record soil and air temperatures. Plant moisture stress determinations and soil assays were made for each plot.

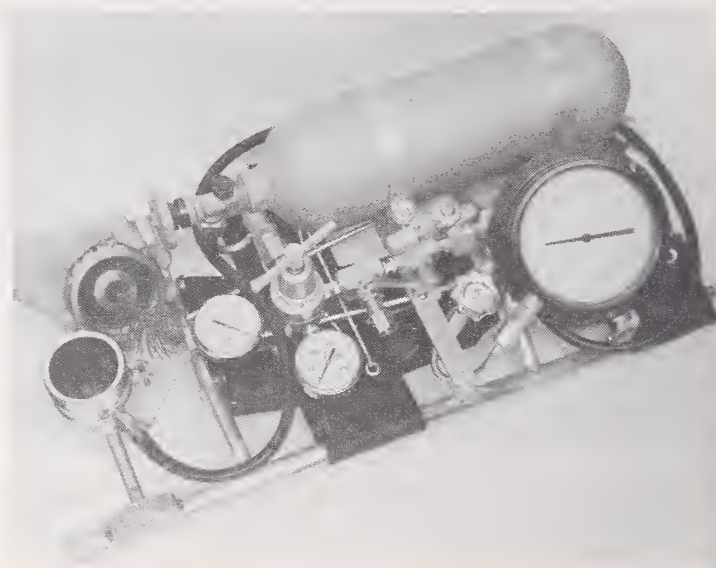


Figure 9. Plant moisture stress is measured by use of portable pressure bomb to select tree species best suited to the site.

#### **SOUTH DAKOTA STATE UNIVERSITY, 452**

**Soil and vegetation of grasslands invaded by ponderosa pine.**

**J. T. NICHOLS**

Production of herbaceous vegetation was sampled in 1969 under ponderosa pine that has encroached on grassland in the past 70 or more years (Figure 10). Forage production was also sampled on adjacent areas on which pine had been cleared by the landowner in 1964 and 1965. On east slopes, production of understory vegetation was nearly 5 1/2 times greater where the pine had been cleared than under the uncleared stands (341 vs. 1,838 lb./acre). On drier, west slopes, (Figure 11) production was nearly 5 times greater in the cleared areas (235 vs. 1,083



lb./acre). The study areas lie immediately north of the Black Hills on escarpment-like hills overlooking the Red Beds (Spearfish formation). Ponderosa pine has increased in both density and abundance under fire protection since that area was settled in the late 1800's. The slow growing trees are of little commercial value and have a pronounced effect on reducing understory vegetation and available water. In the southern Black Hills, grassland areas have soils with morphological characteristics of forest soils. Grassland soils apparently were at one time capable of supporting ponderosa pine. Thus, soils differences are probably not a factor causing stable forest margins. Future areas for intensive study of environmental and/or management changes affecting the grass-pine ecotone will be located by using old photographs, e.g., Custer Expedition to the Black Hills (1874) and others that have been obtained. Photographic documentation will be coupled with field measurements.



Figure 10. Study areas were located on the Hog Back ridge which overlooks the Redwater River north of Spearfish, S.D. The encroachment of ponderosa pine into grassland is evident when the upper photo (taken between 1880 and 1900) is compared with the lower photo (taken September 11, 1969). This rangeland is used in fall and winter by cattle and yearlong by deer and small game.



Herbaceous understory vegetation on west slopes in this stand of low value ponderosa pine averaged 235 pounds per acre.



Forage production averaged 1,083 pounds per acre in 1969 on west slopes following removal of ponderosa pine by the landowner in 1964 and 1965.

Figure 11

#### UNIVERSITY OF WASHINGTON, 6

Ecology and physiology of Douglas-fir and true firs.

D. R. M. SCOTT

Current year's research on assimilation and transpiration has involved two areas of study: (1) use of  $^{14}\text{CO}_2$  to investigate assimilation and translocation of assimilates and (2) the interaction between transpiration and assimilation.



Research has been initiated to learn more about the seasonal source-sink relationships for current photosynthates in Douglas-fir branches. The objective of this research is to develop a source-sink model describing the competition between sinks (growth processes) in the branch and stem for photosynthates from each of the branch's sources (needles of different ages and branch locations).

Noted anatomical similarities between noble fir (*Abies procera*) and Pacific silver fir (*A. amabilis*) coupled with ecologically different patterns of behavior lead to an investigation of possible physiological differences in water use and/or assimilatory behavior between the two species. Field work demonstrated subtle differences in water use and also

established the use of the pre-dawn measurement of stem moisture stress as an excellent indicator of soil water content.

Connected research in a controlled environment chamber using a Siemen's Climate Chamber (Figure 12) as designed by W. KOCH and O. LANGE and an infrared gas analyzer demonstrated a strong relationship between "pre-dawn" needle stress and daily net assimilation ( $r^2 = .85$ ) and for any given level of needle stress, noble fir assimilated less than did Pacific silver fir. (Figure 13) A model was employed to connect the controlled environment data with the field data so as to be able to predict the ecological distribution of the two firs knowing only Penman's potential evaporation.



Figure 12. Some of the foliage of a noble fir (*Abies procera*) is located in the Siemen's Climate Chamber which measures net assimilation and transpiration while controlling temperature and relative humidity. Probes in the stem in the lower left of the picture were used to measure sap velocity.

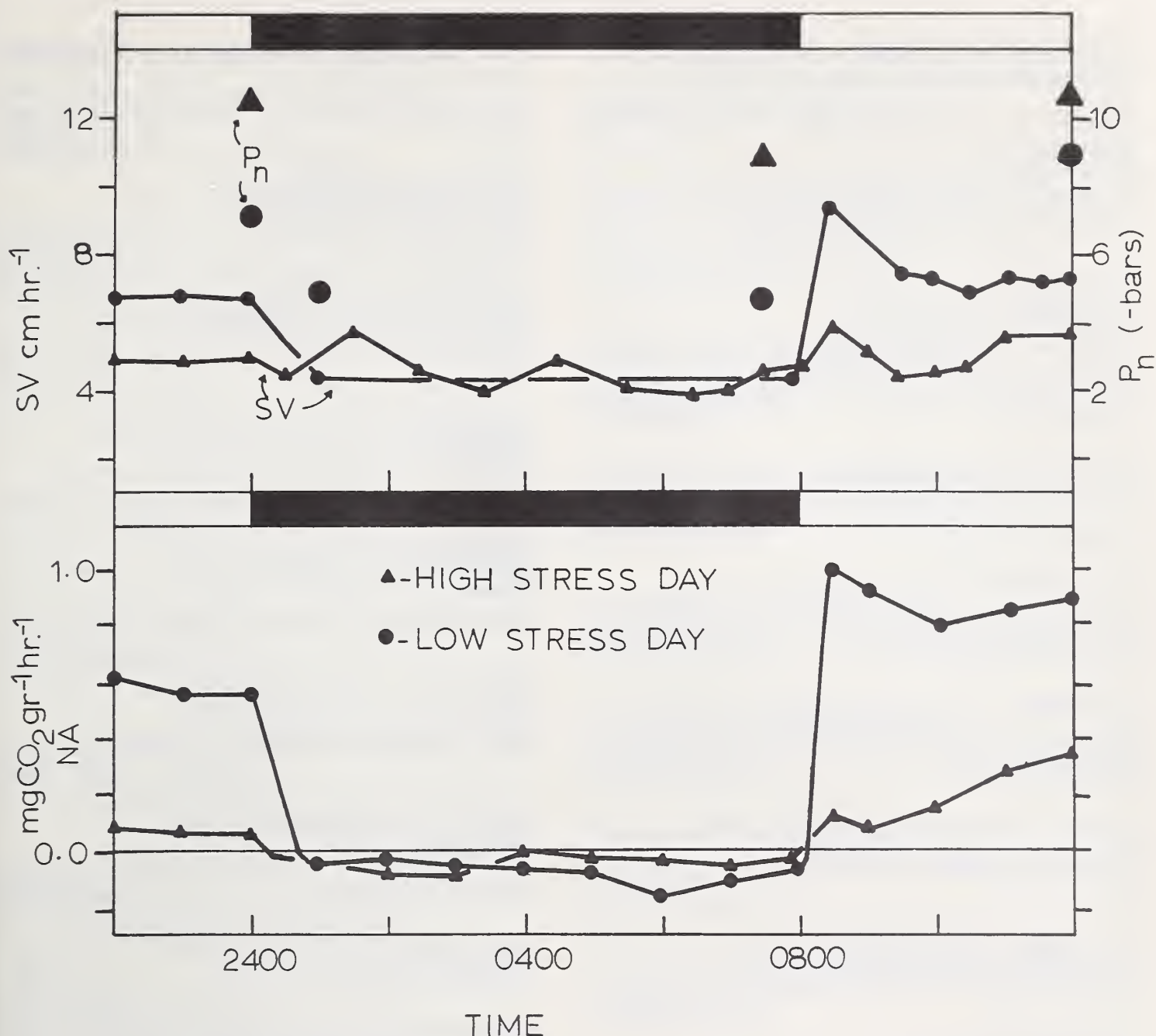


Figure 13. Net assimilation (NA), sap velocity (SV), and needle moisture stress ( $P_n$ ) under high and low stress days in a Pacific silver fir (*Abies amabilis*). Air temperature - 26°C, relative humidity - 45%, and light intensity - 2400 ft. c.

#### ADDITIONAL PROJECTS

ALABAMA - AUBURN UNIVERSITY, 904  
Physiological factors affecting resistance of woody plants to certain phytocides. M. C. CARTER

UNIVERSITY OF ALASKA, 001  
Forest succession and soil moisture retention on upland sites in the Fairbanks area. B. J. NEILAND

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and F. A. VALENTINE

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and L. B. BARNETT

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S. P. GESSEL and T. N. STOATE

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Douglas-fir. J. S. BETHEL

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T. T. KOZLOWSKI

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## GENETICS AND BREEDING OF FOREST TREES

### Research Problem Area 301

Forest practice today is based largely on wild forest trees. Unlike crop plants, trees have not undergone centuries of controlled selection and breeding to make them more useful to man. There is strong evidence that through application of genetic principles we can produce tree varieties that grow faster, resist most major destructive pests, have specified wood properties, or yield more sap or gum. It should be feasible to develop straighter form, fewer limbs and resistance to climatic extremes. Quality and yield of timber-related crops such as naval stores, ample sap and Christmas trees can be improved through application of research findings.

### UNIVERSITY OF FLORIDA, 1293

#### Stock-scion relationships of southern pine.

W. H. SMITH

Failure of grafts to form successful unions can prevent establishment of superior selections in seed orchards. A series of experiments have been conducted in an attempt to define factor influencing grafting. (Figures 14, 15). High nitrogen nutrition of the stock sharply reduces grafting success. An immunosuppressant (decadron and 6-mercaptopurine) and ascorbic acid (polyphenoloxidase inhibitor). Graftability differences failed to develop among controls and treatments. Presumably, this was because an intermittent mist system was employed which resulted in a high proportion of successful grafts generally. Other difficult-to-graft material (sand pine) was greatly aided by this treatment also. Thus, high humidity which prevents scion dessication



Figure 14. Graft showing unequal growth rates of scion and stock.



Figure 15. Grafting of unrelated scion and stock could lead to incompatibility because of dissimilar physiology.



appears to be an extremely important factor in grafting success and can be employed to improve success with difficult grafters.

Biochemical assays of total protein, polyphenoloxidase and peroxidase in graft-union tissue gave an indication that these are potentially useful in detecting physiological problems, e.g. toxic quinones produced by polyphenoloxidase or growth substance differences by peroxidase, or growth-rate differences by protein formation.

#### KANSAS STATE UNIVERSITY, 672

##### Christmas tree production.

R. W. FUNSCH

Superior strains of Christmas trees suitable for Kansas conditions are being sought. The best individuals will then be used in a breeding program. Evaluations were continued of *Pinus sylvestris*.

A Scotch pine provenance study was set out at the Ashland farm. A latin square design with a 6'x6' spacing was utilized. Thirty-nine provenances from ten European countries were included. To date strains from Spain and Latvia appear to be the best performers. A ponderosa pine provenance study (80 sources) set up in 1968 was continued. About 10 of the sources do not appear adapted to the state (Figure 16).

Leaf data obtained were subjected to analysis of variance and multiple regression analyses. The analysis indicated that a certain extent of the variation for each character studied was due to a provenance effect. This was considered to be primarily of genetic nature as the multiple regression analyses did not indicate any environmental relationship.

A large percent of all Christmas trees used still come from outside the state, however, the number of Kansas grown trees will continue to increase.

#### UNIVERSITY OF MARYLAND, L-100

##### Vegetative propagation of pine by needle fascicles.

J. B. SHANKS

Four-year *Pinus-strobus* seedlings receiving natural daylength, long nights, short nights, or continuous light treatments while growing outside from July to October were used as the source of over 12,000 fascicles placed under intermittent mist for rooting following quick-dip treatments with several

concentrations of 2 parts IBA/ 1 part IPA. Maximum rooting (28%) was obtained with fascicles from plants under long nights followed closely by natural photoperiod while short night treatment of plants resulted in poorer rooting. After 120 days, twice as many fascicles (14%) rooted when treated with ½% IBA/IPA than with 1% IBA/IPA or no quick-dip treatment.

Fascicles from three-year *P. ponderosa* seedlings classified for stage of bud development were placed under mist in January. Six percent of the fascicles without buds were rooted, 11% of fascicles with inactive buds were rooted, and 22% of fascicles showing activity in the growth of at least one primary leaf were rooted when examined in July. The degree of bud activity has been observed to be correlated with further growth of both roots and shoots in these young plants (Figure 17).

Current work is concerned with further investigations of the effect of photoperiod on rooting ability and bud activity of fascicles and with the use of growth regulators to aid in the induction of bud activity of fascicles on the plant and during or after the formation of roots.

#### MICHIGAN TECHNOLOGICAL UNIVERSITY, 2-3011

##### Genetic improvement of sugar maple.

R. L. SAJDAK and P. W. GARRETT

A sugar maple provenance test of 23 range-wide sources was outplanted in Michigan's Keweenaw Peninsula during 1968. Information from this planting will be combined with the results of several outplantings established by the Northeast Forest Experiment Station at Burlington, Vermont and other cooperators.

Investigation of the variability in wood specific gravity of sugar maple is continuing. Natural stands throughout the Upper Peninsula of Michigan have been sampled and the results will be compared with samples from the 1954 Sugar Maple provenance test established by the Ohio Agricultural Experiment Station at Wooster, Ohio.



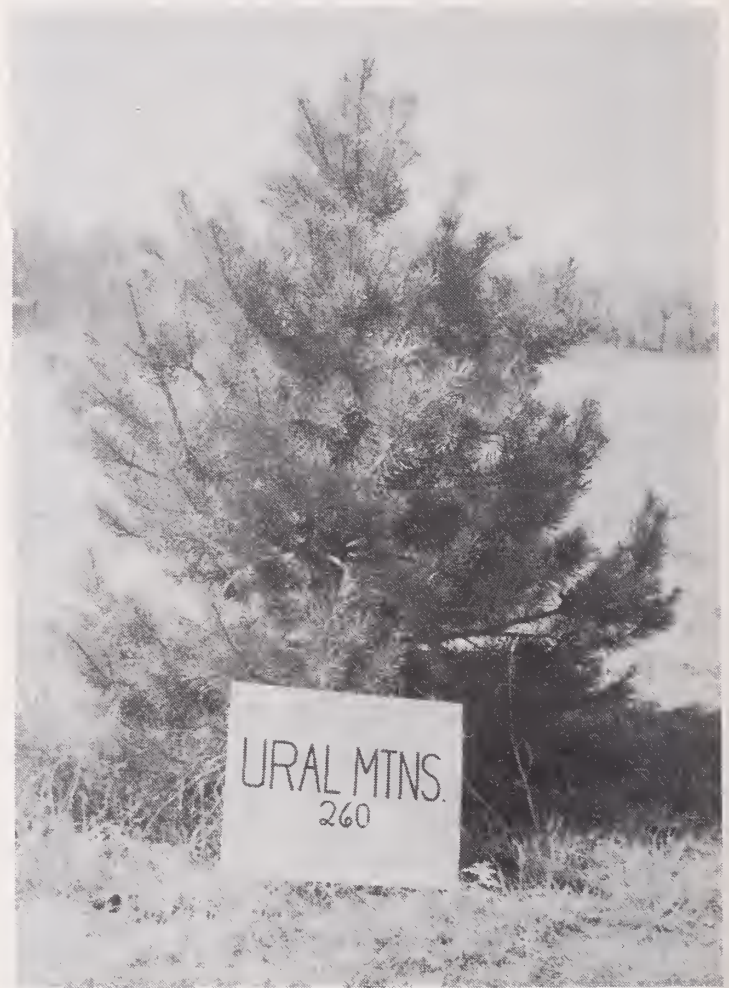


Figure 16. Scotch pine strains varying in both tree form and color.

- A. Selection from Ural mountains (260) - fair form, fair to poor color.
- B. Selection from Latvia (223) good form, fair to poor color.
- C. Selection from Spain (218) good form, good color.





Figure 17. Rooted fascicles of *P. ponderosa* showing a. extent of root system; b. bud not in active growth; c. bud having made primary leaves; d. development of shoot growth and a terminal bud.

The range of wood specific gravity found in 60 trees in one local stand varied from .54 to .65 with a mean of .586. This compared with a range of .49 to .67 and a mean of .585 as reported by Benson Poul based on samples from 70 trees from twelve stands in eight states.

The 60 trees in one local stand were also studied with regard to bark appearance and growth rate. The best single indicator of a tree which has been vigorous throughout its life apparently is relatively thin outer bark. Current vigor based on past 10-year performance is best indicated by a "V" shaped bark furrow with light-colored inner bark showing at the bottom (Figure 18).

#### UNIVERSITY OF MISSOURI, 534

#### Moisture in the artificial pollination of pines.

R. POLK

At the outset the primary objectives of this project were (1) to study the pollination mechanism in *Pinus*, giving particular attention to the role of atmospheric moisture; and (2) to interpret results of various bagging methods for controlled pollination in terms of findings under the first objective. It was soon learned that, although atmospheric moisture does have a strong effect on pollination prospects in *Pinus*, conditions exterior to pollen bags are largely controlling on microclimatic conditions created by bagging. Early procedures included treatments in the irrigation and chambering of trees to create contrasting combinations in soil-moisture and atmospheric-moisture regimens.

Accomplishments have been sufficient to clearly relate a functioning of the *Pinus* pollination mechanism to the availability of soil moisture. Moreover, year-to-year results suggest that a vigorous and active root system, requiring some minimal level of soil aeration, is also highly important. Periods of prolonged and excessive wetness, the effects of which are intensified by poor internal soil drainage, are perhaps even more inimical to *Pinus* reproductive processes than are periods of drouth. In brief, controls of certain edaphic requirements must be obtained before exacting studies of the pollination mechanism and other facets of *Pinus* reproduction can be most meaningfully pursued. A factorial system of subirrigation and drainage plots is being constructed.





Figure 1. Type 1 bark ("platy"). Tree is 22.6 inches d.b.h. at 142 years. Rapid growth rate.

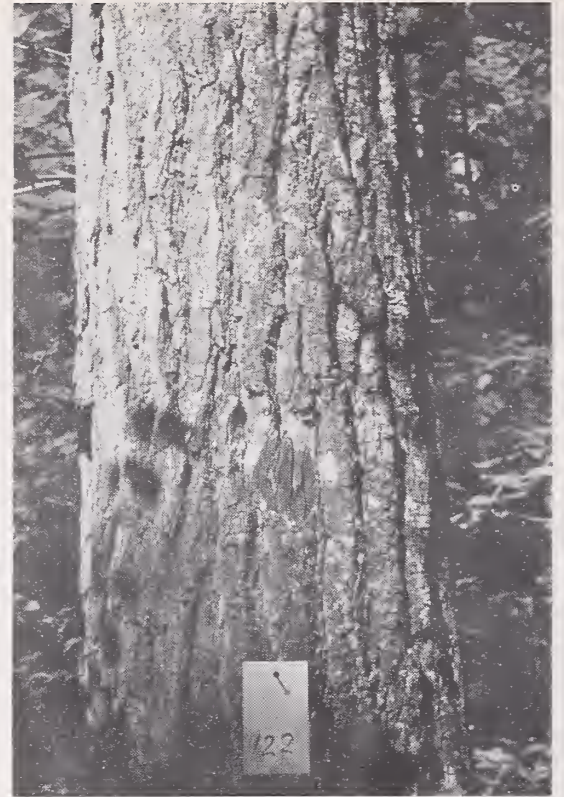


Figure 3. Type 3 bark ("shell"). Tree is 14.4 inches d.b.h. at 129 years. Medium growth rate.

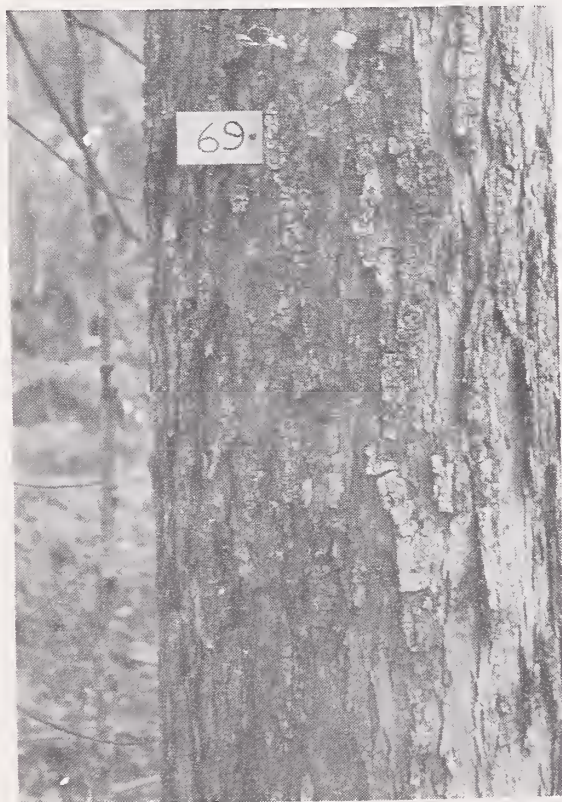


Figure 2. Type 2 bark ("corrugated"). Tree is 20.8 inches d.b.h. at 227 years. Medium growth rate.



Figure 4. Type 4 bark ("ropy"). Tree is 11.5 inches d.b.h. at 83 years. Medium growth rate.



Work under this project is being transferred to the recently revised Project 607: Genetic Investigations in Forestation.

#### **OKLAHOMA STATE UNIVERSITY, 1348**

##### **Evaluation of shortleaf x slash pine hybrids.**

**C. E. POSEY**

In 1966 a field study of shortleaf x slash pine hybrids was initiated at ten locations throughout Region 8 in cooperation with the Institute of Forest Genetics. This study was undertaken in Oklahoma in the hope that a hybrid could be found that would be adapted for commercial production within the range of shortleaf pine in the state.

Four hybrids were planted in Oklahoma. A western shortleaf and slash hybrid and an eastern shortleaf and slash hybrid were included in all plantings. A loblolly x slash pine hybrid and an Oklahoma shortleaf x slash pine hybrid were included only in the Oklahoma planting. Slash pine, Louisiana shortleaf pine, Oklahoma shortleaf pine, and Oklahoma loblolly pine were planted as checks.

Although definitive results must await measurements nearer rotation age, certain observations were made at the end of three growing seasons in the field.

Local loblolly, local shortleaf, and the slash check had greater average growth per tree and higher survival than the other five entries. The western hybrid had much higher survival than the other three hybrids. The eastern hybrid was lowest in average growth per tree than the other three hybrids.

All species except slash pine demonstrated some degree of tipmoth attack on every tree. Only 88% of the slash pine were attacked. Slash pine demonstrated light damage on 57% and moderate damage on 29% of the trees. Only 2% were classed as heavily damaged. In contrast, Oklahoma shortleaf and loblolly, and the eastern hybrid had greater than 74% classed as heavily damaged. The western hybrid was less severely attacked than the other three hybrids.

#### **SOUTH CAROLINA - CLEMSON UNIVERSITY, 705**

##### **Inbreeding in Virginia pine.**

**R. E. SHOENIKE**

(1) 1967 collections. Seedlings were planted in a randomized block design on an old field on the

Clemson Forest after competing vegetation was removed. A survival count was made in September 1969.

(2) 1968 collections are currently being grown as seedlings in a S.C. State Forestry Commission Nursery. These to be planted in 1970.

(3) 1969 collections were obtained from 35 trees in October 1969. Seed is currently being extracted and will be sown in a nursery in 1970.

#### **UNIVERSITY OF TENNESSEE, 8**

##### **Christmas tree breeding.**

**E. THOR**

Evaluation of nine species and numerous seed sources is carried out in several locations. More than 10,000 trees are evaluated for characteristics such as survival, growth rate, needle color, needle length, disease and insects, and Christmas tree grade. A total of 13 seed source tests have been established with Scotch pine, Norway spruce, Douglas-fir and Austrian pine. Eastern white pine appears to be the most promising Christmas tree species in Tennessee, producing a seven-foot dense tree in seven years (Figure 19). However, only the southernmost seed sources will grow that vigorously. Scotch pine and Norway spruce may also be grown successfully in most parts of the State. Scotch pine from Central Europe grow much faster than trees from more southern sources (France or Spain), but their needles are long and coarse, turning yellow in late fall. Douglas-fir suffers damage from spring frosts in Tennessee, and mortality is heavy in frost pockets; there are no significant differences among sources in this respect. White fir and Fraser fir are relatively slow growing, requiring at least 10 years to produce a dense seven-foot tree. Both species are adapted only to the higher elevations in Tennessee, suffering heavy mortality in plantations below 3000 feet elevation.

### **ADDITIONAL PROJECTS**

#### **ALABAMA - AUBURN UNIVERSITY, 901**

##### **Within-tree variation in cell anatomy.**

**J. F. GOGGANS**

#### **ALABAMA - AUBURN UNIVERSITY, 903**

##### **Improved forest trees for Alabama.**

**J. F. GOGGANS**





Figure 19. White pines early in the seventh growing season are almost ready for harvest while blue spruce (foreground) are less than three feet tall.

**ALABAMA - AUBURN UNIVERSITY, 912**

Genetics, breeding and evaluation of certain forest trees in Alabama. J. F. GOGGANS

**CALIFORNIA - HUMBOLDT STATE COLLEGE, 11**

A provenance study on Coast redwood. D. THORNBURGH

**COLORADO STATE UNIVERSITY, 311**

Genetic potential of Rocky Mountain tree. G. H. FECHNER

**COLORADO STATE UNIVERSITY, 319**

Crossability and compatibility patterns in Spruce. G. H. FECHNER

**UNIVERSITY OF FLORIDA, 1344**

Improvement of sand pine for reforestation of the Florida sandhills. R. K. STRICKLAND and R. E. GODDARD

**UNIVERSITY OF IDAHO, 3**

Heritability and population structure of ponderosa pine. C. W. WANG

**UNIVERSITY OF SOUTHERN ILLINOIS, B-1-69**

Structural studies of early and delayed graft incompatibility in juglans. M. KAEISER

**UNIVERSITY OF SOUTHERN ILLINOIS, 69-R-011**

Genotypic variation in black walnut. P. L. ROTH

**MICHIGAN STATE UNIVERSITY, 936**

Mineral nutrition of trees related to genetic variation. J. W. HANOVER

**UNIVERSITY OF MINNESOTA, 19-78**

Hybridization studies in populus. S. S. PAULEY

**UNIVERSITY OF MISSOURI, 607**

Genetic investigations in forestation. R. B. POLK



- UNIVERSITY OF MONTANA, 904  
Hybridization of western and sub-alpine larch.  
G. M. BLAKE
- UNIVERSITY OF NEBRASKA, 20-28  
Tree breeding.  
W. T. BAGLEY
- NEW YORK - STATE UNIV. COLLEGE OF FORESTRY AT SYRACUSE UNIV., 301-1-1  
Variability in wood quality in forest trees.  
W. T. GLADSTONE
- NORTH CAROLINA STATE UNIVERSITY, 4010  
Physiological basis for genotype productivity.  
T. O. PERRY
- NORTH CAROLINA STATE UNIVERSITY, 4011  
Soil nutrients and seed source for optimum sweetgum plantations.  
J. W. JOHNSON
- NORTH CAROLINA STATE UNIVERSITY, 4015  
Geographic variability in yellow-poplar.  
R. C. KELLISON
- NORTH CAROLINA STATE UNIVERSITY, 4016  
Taxonomic relationship of *P. rigida* and *P. serotina*.  
L. C. SAYLOR
- NORTH CAROLINA STATE UNIVERSITY, 4023  
Variation of white oak in the Southern Appalachians.  
J. W. HARDIN
- OHIO AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER, 2  
Seed development in white pine in relation to sterility barriers, inbreeding depression and hybrid vigor.  
H. B. KRIEBEL
- OKLAHOMA STATE UNIVERSITY, 1241  
Clinal variation in shortleaf pine.  
C. E. POSEY
- OKLAHOMA STATE UNIVERSITY, 1304  
Improved loblolly and shortleaf pine.  
C. E. POSEY
- OKLAHOMA STATE UNIVERSITY, 1349  
Cottonwood improvement.  
C. E. POSEY
- OREGON STATE UNIVERSITY, F-759  
Inter-and intra-family variation in Douglas-fir.  
H. IRGENS-MOLLER
- OREGON STATE UNIVERSITY, F-760  
Comparative development of Douglas-fir seed from high and low elevation trees.  
W. P. WHEELER
- OREGON STATE UNIVERSITY, F-762  
Flower induction on juvenile Douglas-fir.  
K. K. CHING and D. P. LAVENDER
- SOUTH CAROLINA - CLEMSON UNIVERSITY, 704  
Genetics of forest trees.  
R. E. SCHOENIKE
- SOUTH CAROLINA - CLEMSON UNIVERSITY, 717  
Variation and tree improvement studies in the genus *quercus*.  
R. E. SCHOENIKE
- SOUTH CAROLINA - CLEMSON UNIVERSITY, 881  
Variation and inheritance of longleaf pine.  
R. E. SCHOENIKE
- UNIVERSITY OF WASHINGTON, 16  
Genetic studies of Pacific Northwest hardwoods.  
R. F. STETTLER
- WASHINGTON STATE UNIVERSITY, 1771  
Genetics of multinodalness in lodgepole pine.  
R. M. DINGLE
- WEST VIRGINIA UNIVERSITY, 1  
Selection, propagation, and silvicultural regeneration of genotypes of hardwood tree species.  
F. C. CECH
- UNIVERSITY OF WISCONSIN, 1262  
Cross and self-incompatibility in trees.  
D. T. LESTER

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## FUR BEARING ANIMALS, WILDLIFE, AND FISH AND OTHER MARINE LIFE

### Research Problem Area 904

Research on wildlife, fur-bearing animals, fish and other marine life is needed to meet the ever growing demands of hunters, trappers, and fisherman; to develop improved production of farm reared fish and fur bearing animals; and to assure continuing supplies of marine life for food and other purposes.

To maintain and increase the supply of wildlife, fish, and other marine life it is essential to know how to maintain and enhance their habitat, and to determine the biological requirements and relationships of each species, including cover and food for normal growth.

Increased knowledge of fish biology is needed to put commercial production of fish in farm ponds and lakes on a paying basis.

### UNIVERSITY OF GEORGIA, 20

An evaluation of radioactive contaminants in wild animals of forest lands. J. H. JENKINS

We are now pinpointing the radiation accumulation areas. We analyzed 383 deer from the Southeast this past year by requesting the Game and Fish Commission to save a sample from all road kills. This was suggested to us by the U.S. Public Health Service. We know now about where and when radioactivity occurs in deer from fallout biomagnification. We also check deer from six locations every three months. We have found that Cesium 137 accumulation can sometimes be high in bobcats, raccoons, squirrels, and a few fish species. In general, birds accumulate very little radioactivity. Some wildlife species have a body burden over 300 times that of beef in the Southeast. It is doubtful that wildlife poses much hazard to people since we do not depend on it ordinarily as a

steady food source. However, we should definitely know the mechanics involved in bioaccumulation. Stomach contents of 135 deer were analyzed for radiation. We checked over 200 plant specimens and have taken over 60 soil samples. Work is continuing to ascertain the bioaccumulation factors.

### SOUTHERN ILLINOIS UNIVERSITY, CW-7-67

Dispersal of white-tailed deer (*Odocoileus virginianus*) from family units. W. D. KLIMSTRA

Previous study of the white-tailed deer herd on Crab Orchard National Wildlife Refuge in southern Illinois has suggested that a substantial number of deer disperse annually. Thus, a project was initiated to study the pattern and rate of this dispersal.

In 1969, eighty-five deer (6 adult males, 21 yearling males, 8 adult females, 11 yearling females, 17 male fawns, and 22 female fawns) were captured primarily with cannon-projected nets, individually marked, and released. Twelve of these, 7 yearling bucks and 5 buck fawns, were equipped with collar-transmitters (Fig. 20), and their movements were monitored once or twice daily. Over 2,500 subsequent sightings were recorded for marked deer.

Yearling bucks continued to use essentially the same ranges throughout the summer as those used previously as fawns; however, they became secretive and were not observed as often as when fawns. In mid-October the first dispersal activity was noted when two radio-marked yearling bucks moved about 1 mile each but returned within a day. During the rut in November and December 14 of 17 (82 percent) yearling bucks dispersed up to 4.0 miles from original ranges as shown by radio-locations; two were harvested off the study area during the hunting season. Three radio-marked yearling bucks made wandering movements of 1.5 to 3.0 miles but returned to their original ranges; further observation should determine their permanent ranges.

Four of 16 (25 percent) yearling does (19-23 months old) dispersed. These deer were thought to have emigrated just prior to the fawning season. Two were harvested 4.2 and 5.7 miles from original capture sites.

This study substantiates that a large percentage of yearling bucks and lesser percentage of yearling does dispersed from the study area annually. Dispersal of yearlings was probably related to the low ranking





Figure 20. White-tailed deer with collar attached radio-transmitters.



they occupied in the social hierarchy. In males, it was manifested during the breeding season when competition for mates was extreme; with females, dispersal was probably because of weakened family ties and attempts to find fawning territories unoccupied by dominant does.

Our studies have shown that dispersal is important to the Crab Orchard deer herd, and probably to most non-yarding deer herds, in controlling and redistributing the population thus preventing decimation of the habitat and consequently the herd itself. Because of this behavior, refuge areas contribute to surrounding deer populations, especially those subjected to annual harvest. Also, the necessity for herd reduction on refuges is lessened.

#### **UNIVERSITY OF MINNESOTA, 17-85**

##### **The effect of small mammals on forest reseedling.**

**J. R. BEER**

During the summer of 1968 there was a good cone crop but unlike other areas in Minnesota seed production was poor. The seed traps showed that only about 5 grams of seed per acre reached the ground. The total seed production as measured by ground level seed traps was only about 10 grams per acre. The litter samples showed that there was some loss of seed over winter but the results were not statistically significant. Small mammal populations were also very low as they have been for 3 years.

#### **NEW YORK - CORNELL UNIVERSITY, 904**

##### **Evaluation of New York State Fish and Wildlife Management Act.**

**L.S. HAMILTON and J. W. KELLEY**

Study has been completed. Report and recommendations made Nov. 1 to N.Y.S. Fish and Wildlife Management Board. A series of 51 hypotheses concerning program functioning were tested by review of 431 reports of Regional and State Board meetings, by personal interviews with 75 program administrators, field personnel and lay leaders, by mail questionnaire response from 63 percent of 441 former and current board members and by personal interview with a 17.5 percent random sample of cooperating private landowners (112) whose lands were under the program. The results permitted a total characterization of the program after 10 years of operation for the first time in its history. They also formed the basis for a series of 18 recommendations for change in the program.

The recommendations made are currently undergoing study by the agency administrators and the layman leadership of the boards, and have been well received. Change toward improvement is assured.

Recommendations touched such subjects as: development of a departmental policy for future, definition and codification of duties of boards, training program for new board members, in-service school for departmental personnel, sorting out of responsibility for cooperator areas vis a vis law enforcement and biologist personnel, newsletter for cooperators, recognition of outstanding cooperators, development of regional plan of action, increased emphasis on fishery resource, increased attention to non-consumptive uses of wildlife, and action to achieve better coordination with other organizations, especially the Conservation Council, Extension Service and County Supervisors. Possibilities of regional coordination with Forest Practice Boards and Soil and Water Conservation District Boards are discussed to the end that integrated land use programs might be achieved.

#### **UNIVERSITY OF RHODE ISLAND, 953**

##### **Movement and activities of white tail deer in relation to extant and concurrent forest alteration.**

**J. J. KUPA**

The survival of the white-tailed deer as a renewable natural resource in densely populated urban states depends on an accurate knowledge of the ecology of the deer and its relationships to man.

White-tailed deer live in densely forested places where they are difficult to observe, therefore, to obtain data concerning their ecology it has been necessary to use advanced techniques for their study. In Rhode Island, wild deer have been captured and individually marked with discrete radio-frequencies that are supplied by miniature, collar attached radio-transmitters (Figure 20) which permit observers operating remote radio-direction finding equipment to triangulate the deer's location.

The study has obtained data on the distances that deer travel, their rates of movement, activity patterns and fidelity to locations by time. Measurements of spatial use by time intervals are available as are correlations of weather conditions with deer movements. The vegetation composition of the ranges of marked deer has been determined and vegetation use



and preference analysed from daily, monthly and seasonal aspects.

New techniques for interpreting deer behavior on a remote basis include the development of deer-carried microphones that permit the correlation of deer-related sounds to specific behavior i.e. cud chewing, browsing, breathing, etc.; and, the use of radio-transmitter frequency changes for interpretation of deer-physical actions.

The data obtained by the study are necessary in the formulation of long range management programs to maintain populations of white-tail deer in rapidly changing environments.

#### **UNIVERSITY OF VERMONT, 7**

**Habitat management and population dynamics of wood ducks.**

**R. W. FULLER**

Field work for most phases was completed. Lack of natural nesting cavities is a limiting factor to sustained presence of wood ducks in Vermont. Artificial nesting boxes are the key to maintaining high, harvestable populations on major breeding areas. The strength of migrational homing peculiar to this species and its breeding season attachment to specific natal areas (revealed through tagging and banding) may explain the prolonged absence of breeding populations in new or restored wetlands; it emphasizes the importance of management with adequate protection for local breeding populations it suggests that populations may be re-established more rapidly in unoccupied habitats by transplanting broods than by adult pioneering. Radio tracking of brooded females under conditions of abundant and scarce brood cover produced data on temporal and spatial movement; this was limited to a 3-week period of early brood life by a design weakness in transmitter antennae. Although behavior influences require further study, transmitter attachment permitted females to enter or leave nesting boxes and to fly with apparent ease (Figure 21); survival rate for broods of instrumented females corresponded with that for broods of normal females. Improved transmitter design will extend this final phase of the study over the entire brood period of 1970, providing a quantitative basis for future cover management. Detailed cover maps of the telemetry study area were prepared. Over 1000 wood duck bandings were added to the existing pool for evaluation of mortality and migration patterns.



Figure 21. Miniaturized transmitters are employed to track movements of wood ducks in relation to available cover.

### **ADDITIONAL PROJECTS**

#### **UNIVERSITY OF CONNECTICUT, 340**

**Fetal sex ratio and productivity of white tailed deer.**

**R. D. McDOWELL**

#### **UNIVERSITY OF CONNECTICUT, 376**

**Habitat analyses of two Northeastern cottontails.**

**R. D. McDOWELL**

#### **UNIVERSITY OF FLORIDA, 1032**

**Ecology of wildlife using sites mechanically prepared for pine planting.**

**S. L. BECKWITH**

#### **UNIVERSITY OF GEORGIA, 11**

**Rabbit population response to small food patches in a Piedmont woodland environment.**

**J. H. JENKINS**

#### **UNIVERSITY OF GEORGIA, 12**

**Quail populations in relation to land succession.**

**J. H. JENKINS**

#### **LOUISIANA STATE UNIVERSITY, 1356**

**Population studies of penned swamp rabbits in hardwood forests.**

**F. W. MARTIN**

#### **UNIVERSITY OF MAINE, 5005**

**Influence of deer upon vegetation.**

**S. D. SCHEMNITZ**

UNIVERSITY OF MASSACHUSETTS, 5  
Food and shelter requirements of ruffed grouse in  
relation to energy regimes. R. B. BRANDER

MICHIGAN STATE UNIVERSITY, 982  
The ecology of shrubs of wildlife food and aesthetic  
value. L. W. GYSEL

MICHIGAN TECHNOLOGICAL UNIVERSITY,  
2-3014  
Ecology of a deciduous deeryard in Keweenaw  
County, Michigan. N. F. SLOAN

NEW MEXICO STATE UNIVERSITY, 2  
Effect of range and water on mule deer population.  
J. E. WOOD

NEW YORK - CORNELL UNIVERSITY, 902  
Infrared detection of simulated animal damage on  
conifers. L. S. HAMILTON and P. A. MURTHA

NEW YORK - CORNELL UNIVERSITY, 907  
Techniques for establishing vegetation for utilization  
by wildlife. J. W. GASLICK

NEW YORK - STATE UNIV. COLLEGE OF FOR-  
ESTRY AT SYRACUSE UNIV., 401-6-1  
Chemistry of aquatic plants. R. T. LaLONDE

NEW YORK - STATE UNIVERSITY COLLEGE OF  
FORESTRY AT SYRACUSE UNIVERSITY, 904-2-4  
Deer habitat studies. D. F. BEHREND

NORTH CAROLINA STATE UNIVERSITY, 4020  
Ecology studies of forest wildlife.  
F. S. BARKALOW

OKLAHOMA STATE UNIVERSITY, 1442  
Compatibility of game and timber production on  
intensively managed lands. J. LAMAR TEATE

UNIVERSITY OF RHODE ISLAND, 955  
Wildlife telemetry in forest environments.  
E. F. PATRIC

UNIVERSITY OF TENNESSEE, 3  
Quail management on forest and associated lands in  
West Tennessee. R. W. DIMMICK

UNIVERSITY OF TENNESSEE, 6  
Wood duck ecology in East Tennessee.  
R. W. DIMMICK

UNIVERSITY OF TENNESSEE, 11  
Physiological responses of wildlife to different forests  
and associated habitats. M. R. PELTON

UNIVERSITY OF TENNESSEE, 12  
Ecology and behavior of the black bear community in  
the Great Smoky Mountains National Park.  
M. R. PELTON

VIRGINIA POLYTECHNIC INSTITUTE, 636121  
Effects of selected disturbance treatments in oak-  
hickory stands on deer browse.  
B. S. McGINNIS and H. S. MOSBY

VIRGINIA POLYTECHNIC INSTITUTE, 636124  
Effect of nutrient levels on reproductive function in  
white-tailed deer. R. L. KIRKPATRICK

VIRGINIA POLYTECHNIC INSTITUTE, 636136  
Simulations of forest game population structure and  
dynamics. R. H. GILES

UNIVERSITY OF WYOMING, 31-70  
Ecology and carrying capacity of summer elk range.  
A. A. BEETLE

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## Chapter II

# SILVICULTURE

As presented in the Oxford System, there are seven primary subheadings of silviculture including the following: Silvicultural systems, regenerating and formation of stands, tending of stands and trees, treatment of defective stands, combined forestry and agriculture (grazing and shelterbelts), arboreta, and management for forest products other than wood such as Christmas trees, nuts, resin, and sugar.

Silvicultural research is intended to solve practical problems in producing and caring for forests; its objective is to find better ways of dealing with problems. Some of the scientific techniques and apparatus used in silvicultural research are quite complex and sophisticated. As more funds for forestry research become available, the level of refinement in technique and apparatus also advances, providing more complete and dependable solutions to the problems of producing more wood and services per unit of land to satisfy the rising demand.

### BIOLOGY, CULTURE, AND MANAGEMENT OF FORESTS AND TIMBER-RELATED CROPS

#### Research Problem Area 111

Culture and management are directed at producing adequate supplies at reasonable cost, by methods that harmonize with other forest uses. For the 40 important commercial timber types in the United States, it is necessary to develop techniques for intensive culture on the most accessible and productive sites; and methods for combining timber culture with other uses on the remaining sites. The major job is to find out how to convert wild forests to managed forests of better species, higher quality, and faster growth in the shortest time and at least cost. Each type, including Christmas trees, has distinctive silvicultural characteristics. Research devises improved cultural techniques

for the more than 130 commercial timber species, and better methods for forecasting growth and quality changes in relation to management practices, thus providing the basis for selection of economic alternatives.

**CALIFORNIA—HUMBOLDT STATE COLLEGE, 16**  
**A growing stock thinning test of Douglas-fir and**  
**associated species.**

**E. W. PIERSON,**  
**and D. A. THORNBURGH**

A 17-year-old uniform stand of Douglas-fir and redwood has been selected as the location for the first set of levels-of-growing-stock plots. Square 1/5 acre plots were laid out with a range of five spacings (4x4, 8x8, 12x12, 16x10, 20x20) plus a control plot. Species composition on the plots is controlled at three levels, pure redwood, 1/2 redwood and Douglas-fir, and pure Douglas-fir. At the present time



all the plots have been thinned and the initial tree measurements will be taken before the start of the spring growing season.

**SOUTHERN ILLINOIS UNIVERSITY, 64-R-004**  
**Hardwood planting on upland old-field in Southern Illinois.**  
**C. A. BUDELSKY**

This investigation is an evaluation and further documentation of a means to accelerate the conversion of abandoned farm land, common to southern Illinois, to productive forests.

Average total height growth after five growing seasons was significantly greater (at 1% level) when the competitive vegetation was reduced than in the non-cultivated control. Sycamore and sweetgum were tallest (9.6 ft. and 9.5 ft. respectively), while yellow-poplar and white ash were smaller (7.3 ft. and 7.2 ft. respectively) in the cultivated area. Average annual height increment was significantly greater (at 1% level) during the last four years for all species in the cultivated treatment. There was no difference in percent mortality due to treatment. The major influence of the herbaceous vegetation on tree growth appears to be through competition for available moisture, as indicated by the significantly (at 5% level) lower soil moisture values of the non-cultivated area. Undoubtedly the poor root development of trees in the non-cultivated control intensifies the condition.

**LOUISIANA POLYTECHNIC INSTITUTE, 4**  
**Nuclear methods for determining forest soil site index.**  
**C. G. HOBGOOD and J. KUPRIONIS**

Two north Louisiana soils planted to loblolly pine were chosen for this test. One, a Shubuta fine sandy loam planted in 1939, and the other a Vacluse fine sandy loam planted in 1945. Four replications were installed in each plantation.

A depth density gauge using cesium-137 as a source of gamma rays was used to determine the depth to, thickness of, and density of the least permeable layers. Since the disintegration rate of any one increment of time to the next, a series of nine counts were made and percentages of error computed on counts per unit of time and density of the soil. The nine readings were then computed as an average.

In order to minimize the influence of soil moisture, all counts were made with a moisture content between 12 and 15% moisture as determined by tests of the most compact layer.

Site index for each location is being determined by 3 methods. A five-year record of rainfall, interception, infiltration, and runoff has been accumulated.

All data are being analyzed by computer and differences tested statistically to determine if site index can be measured using the depth density gauge.

**NORTH CAROLINA STATE UNIVERSITY, 4018**  
**Fertilization and Irrigation of seed orchards.**  
**C. B. DAVEY**

Fertilizer and irrigation experiments are being continued in loblolly and eastern white pine seed orchards to test the effects of added nutrients and water on flowering, seed production and seed quality. Experiments on two orchards are factorial tests of complete fertilization and irrigation. Similar experiments in another orchard have been discontinued according to original plans. Experiments in a third orchard test the effects of N, P, and K alone and in combination. Experiments on a third orchard test the effects of N & P in various combinations at rates ranging from 0 to 200 lb/acre/year. Flower and cone counts made in the different orchards indicate increased fruiting occurs with fertilization and with irrigation. In one cone orchard cone production on control plots averaged 17.4 cones/tree compared to 23.8, 41.2 and 66.6 cones/tree on irrigation, fertilization and irrigation plus fertilization plots, respectively. Seed to be examined for quality was collected from three orchards. Foliage samples to be examined for nitrogen and carbohydrate status were collected from two orchards, with both loblolly and eastern white pine being represented. A Ph.D. dissertation project is nearing completion.

**OHIO-AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER, WOOSTER, 1.**

**Effects of fertilizers on sugar maple and tulip-poplar.**  
**J. P. VIMMERSTEDT**

Combinations of 5 levels of nitrogen, phosphorus, potassium and calcium are being tested in pole-sized yellow-poplar plantations, to determine optimum rate of fertilization. The resultant large differences in available nutrients in the soil are reflected in the

nutrient status of the trees. As yet, no combination of rates is clearly optimum for growth. Limestone reduced height growth in the second year after application.

Chlorophyll concentration of mature leaves, measured the fourth growing season after fertilization, increased with increasing rates of nitrogen application (Fig. 22); potassium modified the response. Fertilization may thus increase dry matter production through an increase in leaf chlorophyll.

## CHLOROPHYLL CONCENTRATION

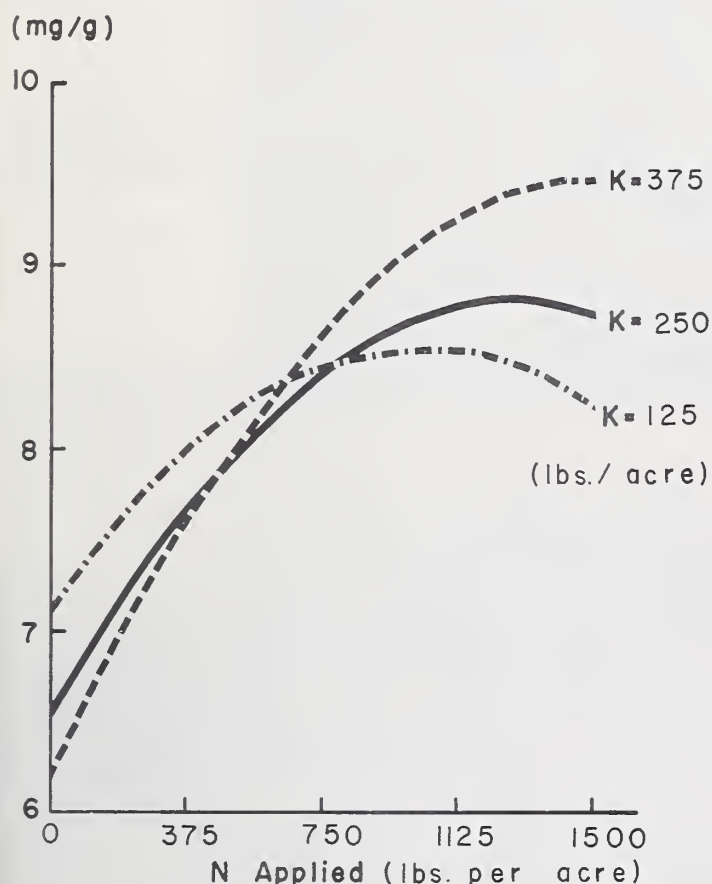


Figure 22. Influence of nitrogen and potassium fertilizers on chlorophyll concentration of yellow-poplar leaves four years after fertilizer application.

It is important to know if fertilization changes wood properties. Accordingly, the pattern of anatomical variation in 5 yellow-poplar stems was studied before fertilization. Within one year's growth sheath, vessel radial width increased fairly rapidly from tip to base. The ratio of vessel wood in the annual ring remained about 22% along the entire sheath. Thus, toward the bottom of the stem, each sheath had fewer, larger vessels than were found higher up. Fiber radial width also increased from tip to base, but the size of the

increase was much smaller. The tree with the largest vessel and fiber width in 1949 continued to have the largest vessel width through 1964 (70% of the time) and the largest fiber width (76% of the time). Knowing about such anatomical variations will help elucidate the effect of fertilization on wood properties.

## PENNSYLVANIA STATE UNIVERSITY, 1805

Stochastic models for simulation of even-aged forest stand systems  
P. E. DRESS

The development of a computational system for the simulation of even-aged forest stand systems over time was completed and a publication describing the system and its use is currently under preparation. This system was tested under a variety of hypothetical stand conditions and was found to be a satisfactory tool for the study of spatial pattern, growth processes, and mortality. The system has been used to test a theoretical model, a bivariate single-stage Markov process, as a model for diameter and height growth and results of this test are quite promising. It is anticipated that this model will be tested with actual data during this year. These results should be of significant value in the development of theoretical regression models for the forecasting of stand conditions over time under varying cultural regimes.

## UNIVERSITY OF TENNESSEE, 4

Forest management determinants. G. R. WELLS

With data provided by the Tennessee Valley Authority, analyses of 274 private, non-industrial forest owners were completed with computer techniques involving factor analysis and other multi-variate statistical procedures. Many findings were in general agreement with the results of other ownership studies. However, one new ownership group with relatively high intensity scores was found. This new group consisted of housewives who now own and control 15 percent of the private, forest resources of the study area. These owners had inherited their property, had families, high family incomes and the interest and wherewithal to carry on some forestry practices. These findings suggest that perhaps current forestry programs are less efficient since they tend to be directed to a declining farm clientele which now make up only 22 percent of the private owners. For example, extension work could be more efficient if programs were tailored to this new group as well as other economic classes of non-farm owners.



An eastern cottonwood plantation was subjected to intensive cultural treatments during two years after planting. Located in the lower Brazos River Valley in Texas, the plantation consisted of three local clones planted at a 7' x 14' spacing.

During the first year irrigation had little effect on growth because of heavy summer rains. Rainfall received the second year was near normal (38") and irrigation resulted in a 6'-7' increase in height growth for all clones. At the end of the first year the best clone averaged 14' in height as compared to 13' for the poorest. Under irrigation total height the second year varied from 30' to 27' for the best and poorest clones respectively.

No increases in growth were noted following application of nitrogen at rates as high as 600 lbs/acre of N.

While these soils are highly fertile, other nutrients may be limiting a response to N. Studies are underway to test for the possibility of a N-P interaction. Under non-irrigated conditions heavy applications of N decreased height growth by 6' for the fastest growing clone.

Root studies showed that; (1) extensive branching occurred when roots passed through a band of N-P fertilizer, (2) soil salinity up to 0.63 mmhos. per cm. resulting from band fertilization did not inhibit root development and (3) depth of planting and cutting size had a positive influence on root initiation and dry matter production.

New studies are in progress which are designed to measure dry matter production of soft hardwoods grown in closely spaced stands under varying cultural conditions, Fig. 23.



Figure 23. Measuring dry matter production of soft hardwoods grown in closely spaced stands.



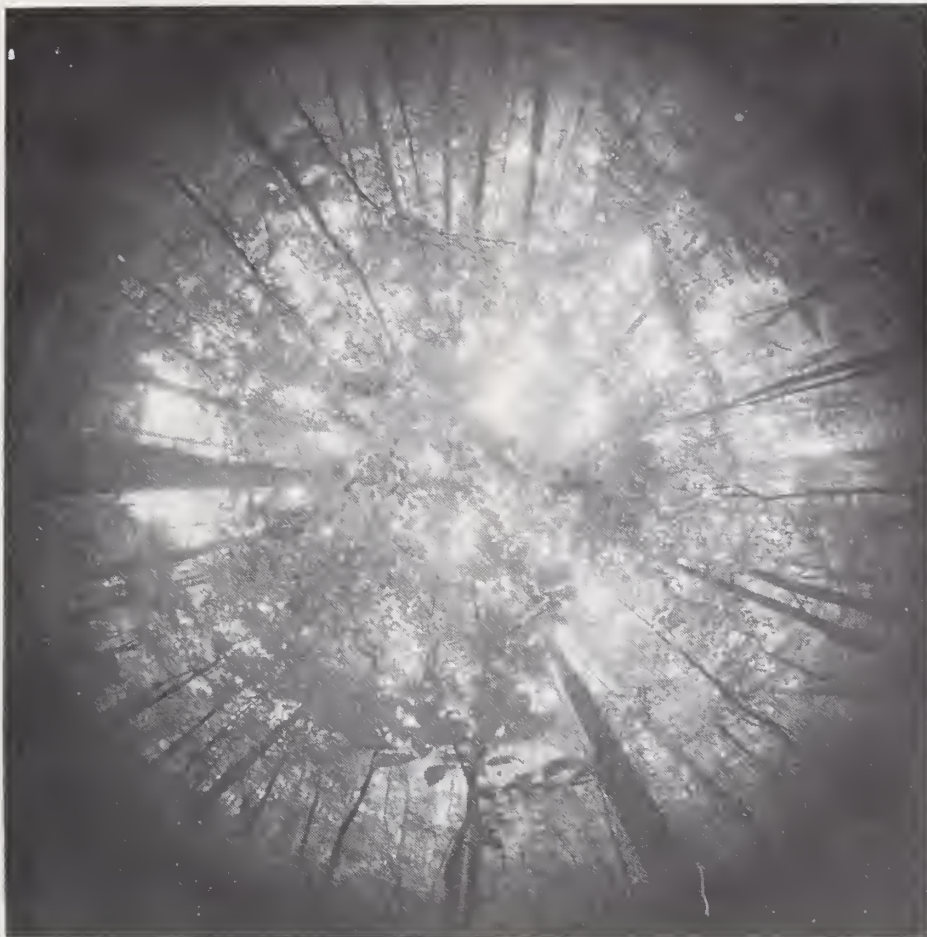


Figure 24. A picture of a pine stand made with a hemispherical camera. These photographs are being used as an index to site parameters.



**UNIVERSITY OF VERMONT, 8****Soil-growth-wood quality of birch. P. R. HANNAH**

Yellow birch poles and saplings occurring naturally in small forest openings and under a hardwood canopy are showing highly variable growth response to amount of release (none, light, heavy). Most released trees accelerated growth the first year. Heavy release poles on the most responsive site increased 2800 sq. mm. in basal area at dbh over 3 growing seasons while control trees increased 1420 sq. mm. Height growth of heavy release saplings on the most responsive site was 470 mm. during the third year; control trees grew 254 mm.

It appears growth responses are most closely related to microsite around individual trees and tree crown vigor. Although neutron probe measurements show generally more soil water around released poles and saplings throughout the growing season than around control trees large variations within treatments are again probably strongly associated with microsite.

Future objectives of this study will be to examine criteria for implementing better evaluations of microsite so higher success ratios of growth response to thinning can be achieved. Attributes of microsite, including soil moisture measurements, and crown vigor classes will be tested for relations to observed growth using multivariate analyses and E.D.P.

**VIRGINIA POLYTECHNIC INSTITUTE, 636120****Parameters of site for certain tree species in Virginia.**

H. A. I. MADGWICK,  
R. STEMPLE, and J. F. HOSNER

Response to fertilization has been measured in *Pinus taeda* plantations in the Virginia Piedmont. Twenty-one plantations ranging in age from 0 to 8 years were surface broadcast with a mixed fertilizer (10-10-10 plus 8% calcium, 0.8% magnesium and 8% sulphur) at the rate of 800 pounds per acre for trees 4 years and older and at 4 oz. per seedling for trees under 4 years. After two growing seasons, oven dry wood weight data indicate that 16 of the 21 plantations fertilized responded favorably to fertilization. Combining fertilizer response with foliar and soil analyses suggests that several elements, notably magnesium, phosphorus and to a lesser extent potassium and nitrogen, appear to be limiting growth. Foliar analyses were more closely related to growth response than were soil analyses.

A study of the estimation of the light climate within forests from hemispherical photographs (Fig. 24) indicated that published methods involved considerable inter- and intra-observer variation. A combination of densiometric measurements and computer programs was developed to estimate percentage light in the forest for six different theoretical sky light distributions. The method was applied to eight photographs from (i) a pine stand and (ii) a hardwood stand in the winter phase. In (i) 99.6% and in (ii) 98.4% of the cosine corrected diffuse light came from a zone of sky within 70% of the zenith. Standard errors increased from 1.5 to 2.5 as estimated light intensity under the canopy increased from 15 to 45% of light in the open.

**ADDITIONAL PROJECTS****ALABAMA - AUBURN UNIVERSITY, 908**

Development of improved practices for nursery production of selected Southern hardwoods.

H. S. LARSEN

**NORTHERN ARIZONA UNIVERSITY, 1**

Ponderosa pine stand density measures.

C. O. MINOR

**CALIFORNIA - HUMBOLDT STATE COLLEGE, 10**

Removal of competing pampas grass from redwood reforestation areas.

D. THORNBURGH

**CALIFORNIA - HUMBOLDT STATE COLLEGE, 12**

The regeneration of redwood following selective cutting.

WILLIAM L. DAVIS

**CALIFORNIA - HUMBOLDT STATE COLLEGE, 18**

Sowing Lupine for better seedling growth and development of planted redwood and associated species.

E. W. PIERSON, D. A. THORNBURGH

**UNIVERSITY OF DELAWARE, 759**

Nutrition of holly understory.

C. W. DUNHAM

**UNIVERSITY OF GEORGIA, 17**

Crown growth and wood formation in loblolly pine.

J. R. BECKWITH

**UNIVERSITY OF GEORGIA, 22**

Quick coppicing hardwoods for fiber yield.

J. T. MAY

- UNIVERSITY OF IDAHO, 10  
Influence of elk and cattle on reforestation.  
F. H. PITKIN
- SOUTHERN ILLINOIS UNIVERSITY, 67-R-14  
Tree suitability for parks and recreation areas.  
D. R. McCURDY
- INDIANA - PURDUE UNIVERSITY, 1476  
Establishment and culture of black walnut, tulip-  
poplar, and cottonwood. W. R. BYRNES
- KANSAS STATE UNIVERSITY, 721  
Hardwood planting on strip mined lands.  
W. A. GEYER
- LOUISIANA POLYTECHNIC INSTITUTE, 1  
Forestry yield data from responses to thinnings of  
natural even-aged stands of loblolly pine.  
E. R. ANDRAULOT, L. P. BLACKWELL  
and J. E. CAROTHERS
- LOUISIANA POLYTECHNIC INSTITUTE, 2  
Effects of annual burning on longleaf pine.  
P. B. MOSELEY  
and L. P. BLACKWELL
- LOUISIANA STATE UNIVERSITY, 1237  
Producing and marketing Christmas trees. B. H. BOX
- LOUISIANA STATE UNIVERSITY, 1266  
Competition in slash and loblolly plantations.  
T. D. KEISTER
- LOUISIANA STATE UNIVERSITY, 1500  
Evaluation of the use of tubelings in regenerating  
southern pine. B. H. BOX
- UNIVERSITY OF MAINE, 5002  
Factors affecting growth of commercial forest tree  
species in Maine. C. E. SCHOMAKER
- MICHIGAN STATE UNIVERSITY, 984  
Optimizing site conditions for the establishment and  
growth of high quality black walnut. D. P. WHITE
- UNIVERSITY OF MINNESOTA 19-18  
Evaluation of tubelings for forest regeneration.  
A. A. ALM
- UNIVERSITY OF MINNESOTA, 19-19  
Development of hazel understories in northern Min-  
nesota forests. J. C. TAPPEINER II,  
and B. A. BROWN
- MISSISSIPPI STATE UNIVERSITY 1120  
Stem form and stand density of loblolly pine.  
R. D. ROSS
- UNIVERSITY OF MONTANA, 302  
Prescribed burning after timber harvesting in the  
Northern Rocky Mountains. R. W. STEELE
- UNIVERSITY OF NEVADA, 671  
Establishing Jeffrey pine on brushy slopes.  
C. M. SKAU and G. A. AHLSTROM
- UNIVERSITY OF NEW HAMPSHIRE, 1  
Cultural practices for balsam fir Christmas tree  
production. P. E. BURNS
- UNIVERSITY OF NEW HAMPSHIRE, 5  
Forest Management control in non-industrial wood-  
lands. R. R. WEYRICK
- NEW YORK - STATE UNIVERSITY COLLEGE OF  
FORESTRY AT SYRACUSE UNIVERSITY,  
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Dynamic models on growth of stands for determining  
allowable cut. T. CUNIA
- OKLAHOMA STATE UNIVERSITY, 1237  
Mortality in commercial timber. T. H. SILKER
- OKLAHOMA STATE UNIVERSITY, 1360  
Control of undesirable woody plants. T. H. SILKER
- PENNSYLVANIA STATE UNIVERSITY, 1487  
Fertilization of forest stands for timber and wildlife  
food production. W. W. WARD
- PENNSYLVANIA STATE UNIVERSITY, 1816  
A short term wood fiber production system.  
T. W. BOWERSOX, W. W. WARD,  
and W. K. MURPHEY
- SOUTH CAROLINA - CLEMSON UNIVERSITY, 706  
Timing of harvest in even-aged timber stands.  
J. R. WARNER
- SOUTH CAROLINA - CLEMSON UNIVERSITY, 789  
Fertilization and irrigation on upland forest.  
W. H. D. MCGREGOR



UNIVERSITY OF TENNESSEE, 1  
Growth of mixed species plantations. E. THOR

UNIVERSITY OF TENNESSEE, 2  
Fertilization and irrigation effects on tree growth.  
E. R. BUCKNER

UTAH STATE UNIVERSITY, 658  
The production of essential oils from the Pinyon-  
Juniper type. W. H. JOHNSON

UNIVERSITY OF VERMONT, 1  
Quality spruce and balsam fir for Christmas tree  
culture. M. L. McCORMACK, JR.

UNIVERSITY OF VERMONT, 2  
Effect of leader damage on growth of planted  
conifers. T. L. TURNER

UNIVERSITY OF VERMONT, 10  
Influence of environment on chemical weed suppres-  
sion in Christmas tree plantations. T. R. FLANAGAN  
and M. L. McCORMACK

VIRGINIA POLYTECHNIC INSTITUTE, 636122  
Growth of mixed hardwoods. J. P. BARRETT

VIRGINIA POLYTECHNIC INSTITUTE, 636123  
Resource use in the Southeastern logging industry.  
D. P. RICHARDS

VIRGINIA POLYTECHNIC INSTITUTE, 636134  
Dry matter production models of forest stands.  
H. A. I. MADGWICK

WEST VIRGINIA UNIVERSITY, 5  
Growth and yield of hardwoods. D. L. KULOW

WASHINGTON STATE UNIVERSITY, 2002  
Growth and yield of even-aged forest stands.  
L. V. PIENAAR

UNIVERSITY OF WASHINGTON, 25  
Relations of wildlife populations to Douglas-fir forest  
characteristics and protection. R. D. TABER

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## IMPROVEMENT OF RANGE RESOURCES

### Research Problem Area 112

Research seeks to maintain and improve the forage-producing capacity of rangelands. Native range in the United States includes over 900 million acres. It represents a continuum of sites and productivity potential from the deserts of the Southwest to the prairies of the Midwest and from the sea-level grasslands of Florida to the Alpine herblands of the high Rockies. Rangelands are important as a source of feed for beef cattle and sheep, in watershed protection, soil stabilization, wildlife habitat, and recreation.

**UNIVERSITY OF IDAHO, 1.**

Site Relationships and Productivity of Foothill Woodland-Shrub Grazing Lands in Idaho.

**E. W. TISDALE**

Study of vegetation dominated by western juniper (*Juniperus occidentalis*) in Idaho has revealed

significant facts concerning the ecological status of this species. Old stands of juniper are confined to rocky soils of ridges and escarpments. Younger stands of juniper, all under 100 years, are found on adjacent areas of deeper and much less rocky soils. These latter stands are increasing in size, and juniper is increasing its dominance within them. The young stands represent invasion by juniper into stands of sagebrush-grass range.

Causal factors proposed for this "juniper invasion" include climatic change, overgrazing and fire. Investigation revealed that only fire shows a direct relationship. We found ample evidence in the form of fire scars and charcoal to indicate that fire was a major factor of the environment in the region for many years prior to white settlement. Presumably the cover of sagebrush-grass vegetation on deep, well-developed soils burned completely and often enough to keep juniper from becoming established. Only on bare, rocky ridges, where fuel was adequate only for patchy ground fires, could juniper establish mature stands. The establishment of white settlement marked the end of uncontrolled fire, and since that time juniper has spread steadily into adjacent sagebrush-grass ranges. This invasion has proceeded about as rapidly on lightly grazed as on overgrazed ranges, and abundance of shrub or herbaceous vegetation was found not to inhibit seedling establishment of juniper.

For land management, it is clear that controlled grazing will not prevent juniper invasion into large areas of sagebrush-grass range, and that forage yields will be greatly reduced by this invasion. Direct control of juniper is needed to preserve grazing values on such areas, and fire is one possible method. The climax juniper type, however, presents a different situation, with open tree stands and low potential for forage production. Such stands have high watershed and esthetic value, and should be left essentially undisturbed.

**NEW MEXICO STATE UNIVERSITY, 1**

Effects of Grazing on Wooded Rangelands in New Mexico.

**R. D. PIEPER**

A comparison of vegetation on three grazed areas with that on comparable areas protected for 12 years on the Fort Stanton Range, revealed that both herbage production and height of blue grama plants were significantly higher on protected areas for all three sites. Species composition was not significantly



different between grazed and protected areas on the hills site, but composition of mat muhly was significantly higher on grazed areas on both bottomland and loamy sites. Composition of blue grama and western wheatgrass was significantly lower on the grazed area on the bottomland site.

Utilization of blue grama decreased from about 45% at water to about 15% at a distance of 1¼ miles from water for the four years of the study. The cattle grazed vine mesquite, sideoats grama and sand dropseed to the heaviest degree, but blue grama comprised the largest portion of the diet because of its abundance. Hairy grama, galleta, wolftail and three-awn grasses were important constituents of the diet while mat muhly was relatively unimportant except for one year.

Vegetative analysis of three sites on Fort Stanton revealed differences in total plant cover, litter cover, bare ground, species composition and total herbage production among the sites. Upland sites were the most productive followed by the shallow and hills sites.

Detailed economic analyses of four ranches in the vicinity of Ft. Stanton revealed that feed costs were the major item of expense. Net ranch income per acre and per animal unit were higher on ranches operated in conjunction with farms where feed was grown.

#### **UNIVERSITY OF WYOMING, 879**

**A study of the forest margins.**

**M. MAY and L. I. PAINTER**

Soil moisture, soil pH, herbage production and vegetative cover were measured during the summer of 1968 on several sites in northwestern Wyoming. The relationship of these factors to stability or instability of lodgepole pine forest margins was determined by stratifying the sampling into three basic sites (mature forest, ecotone and open contiguous park). Surface soil moisture was found to be highest in the mature forest and lowest in the ecotone.

Soil pH decreased from the open area to the mature forest with intermediate value for the ecotone. Although the ecotone had the lowest percentage cover of understory vegetation there was no significant difference in percentage of understory weight produced on the ecotone when compared to the mature forest. Both herbage production and vegeta-

tive cover of understory species was greatest in the open area.

## **ADDITIONAL PROJECTS**

#### **NORTHERN ARIZONA UNIVERSITY, 5**

**Range forage on parks in Ponderosa pine.**

**L. D. LOVE**

#### **UNIVERSITY OF CALIFORNIA - Berkeley, 2500**

**Ecological adjustment of range plant populations to management practices and environment.**

**H. F. HEADY**

#### **UNIVERSITY OF IDAHO, 12**

**Effect of livestock trampling on plant growth and forage productivity.**

**L. A. SHARP**

#### **UNIVERSITY OF MONTANA, 210-603**

**Grazing use and forage yield of forest land in Western Montana.**

**M. S. MORRIS and L. EDDLEMAN**

#### **UTAH STATE UNIVERSITY, 670**

**Range plant foliage removal effects on soil moisture regime.**

**G. B. COLTHARP**

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#### **ARTHUR, J. P., JR. and L. D. LOVE.**

**Environmental measurements in a natural park and in surrounding ponderosa pine stands. Arizona Forestry Note No. 5. Northern Arizona University, Flagstaff. 10 pp. 1969.**

#### **BURKHARDT, J. W. and E. W. TISDALE.**

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#### **BURKHARDT, J. W.**

**Western juniper invasion in southwestern Idaho, an analysis of cause. Ph.D. thesis, Univ. of Idaho. 1969.**

#### **COLTHARP, G. B. and J. C. BUCKHOUSE.**

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## TREES TO ENHANCE RURAL AND URBAN ENVIRONMENT

### Research Problem Area 905

This research provides some of the scientific knowledge required to maintain or improve the quality of the rural and urban environment, and to enhance natural beauty through special-purpose tree planting. Technological change is multiplying the need for special tree planting to screen junkyards and highways, suppress noise, slow the movement of dust and debris, and to provide trees for shade, beauty and shelterbelts to protect crops, animals and faamsteads. Research is needed to find species and techniques so that trees can survive smoke and air pollution, compacted soils, deficient or excess moisture, and other adverse conditions. To end product of concern in this research is a standing tree to enhance the environment.

KANSAS STATE UNIVERSITY, 668

Windbreak influences.

W. A. GEYER

The response of 12 tree species planted in shelterbelts to environmental and cultural factors 30 to 35 years after planting were recorded. Data was collected from 225 windbreaks growing in southcentral Kansas. No significant differences occurred in survival and vigor among spacing distances utilized. Grazing and lack of maintenance caused heavy tree losses. Best adapted

species as measured by survival and growth on all sites included ponderosa pine, eastern redcedar, green ash, osage orange, and bur oak. Cottonwood, Siberian elm, honeylocust, catalpa, and Russian olive performed satisfactorily on lowlands only. Poorly adapted species included hackberry and Russian mulberry.

NEW YORK - CORNELL UNIVERSITY, 903

Suburban forest ownership.

L. S. HAMILTON

Field research is basically complete. Results are currently being analyzed, reviewed, and prepared for final report.

## ADDITIONAL PROJECTS

UNIVERSITY OF NEBRASKA, 20-23 Windbreak shelter effects.

W. T. BAGLEY and N. J. ROSENBERG

NORTH DAKOTA STATE UNIVERSITY, 12-1

Establishment, maintenance, and effects of shelterbelt in North Dakota.

E. P. LANA

SOUTH DAKOTA STATE UNIVERSITY, 475

Selection and propagation of woody plants for the Northern plains.

D. E. HERMAN

SOUTH DAKOTA STATE UNIV., 420

Establishment of Tree Plantings to Enhance Recreation Potential of Selected Sites

P. E. COLLINS

## PUBLICATIONS

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Ecological Factors Affecting Survival and Performance of Tree Species in Kansas Shelterbelts. Ph.D. Dissertation, Kansas State University, Manhattan, Kansas. 1968.



## Chapter III

# FOREST HARVESTING AND ENGINEERING

Forest harvesting and engineering deals with men, machines, and techniques for felling, logging, and transporting harvested trees to processing points. Other topics covered include degree of utilization and forest waste material, intermediate storage of wood in the forest, performance measurements, and forest engineering.

Some of the improvements being investigated in these areas will lead to more efficient and safer means of doing woods jobs than are currently practiced.

Chronic problems of work performance and production efficiency for woods workers will need to be thoroughly examined in order to systematically determine least-cost methods of producing wood. This should be interpreted to include the reduction of waste in the woods. Engineering techniques will probably be employed to supply most of the procedure that will decrease the costs of producing a given unit-volume of wood.

### NEW AND IMPROVED FOREST ENGINEERING SYSTEMS

#### Research Problem Area 302

Improved forest engineering systems can reduce timber harvesting costs, increase and stabilize rural payrolls, reduce accidents and provide higher returns to industry. Over 100 billion board feet of timber in Alaska and the western states are inaccessible due to the high cost of road construction, steep terrain, soil conditions, and lack of equipment suitable for timber harvesting. In other States, because of the high proportion of small-size timber and the high percentage of defective timber, the economic feasibility of harvesting is limited.

#### LOUISIANA STATE UNIVERSITY, 1444

The development of timber harvesting systems for the Gulf South. R. W. McDERMID

Interviewed selected company officials involved with timber procurement in most of the South.

Directed research of 5 graduate students under this project. Prepared quantitative economic decision model to determine alternative costs of pulpwood chips produced by slashing vs chipping of long pulpwood.

Determined that productivity of hydraulic tree-shears is significantly affected by two variables: 1. average volume of trees cut per acre (73.7% of variation) and 2. operator skill (12.7%).

Determined, through simulation study, that use of a tethered balloon system will permit production of pulpwood under southern swamp conditions at economically marginal costs, under current market conditions.

### ADDITIONAL PROJECTS

MICHIGAN TECHNOLOGICAL UNIVERSITY, 5  
Pulpwood skidding time analysis. H. M. STEINHILB

## PUBLICATIONS

McDERMID, R. W.

Timber harvesting systems and training techniques employed in the southern United States of America. United Nations-FAO/ECE/ILO LOG/WP 7/24/Revl. June. 1969.

STUCKEY, H. J.

Cost comparisons of chipping versus slashing in pulpwood production in Arkansas. Master's Thesis,

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The feasibility of balloon logging in a Louisiana swamp. LSU Forestry Note No. 86. November. 1969.

WHITE, M. C., R. R. FOIL, and R. W. McDERMID.

Tree volume affects productivity of hydraulic tree-shears in southern logging. LSU Forestry Note No. 85. October. 1969.



## Chapter 4

### FOREST INJURIES AND PROTECTION

Research described in this chapter deals with the well-known sources of damage to forests including fire, insects, and diseases, and could include diverse and unusual types from avalanches to volcanic ash. The techniques for protecting forests from injuries are also found in this chapter.

Research Problem Area 201, Control of Insects Affecting Forests, includes all the fundamental aspects of forest insects and associated organisms, selection and breeding of trees for resistance to insects, plus control techniques that involve safer chemicals and biological controls. Control of Diseases, Parasites and Nematodes Affecting Forests is the title for RPA 202. Research in this problem area is also integrated from fundamental studies of pathogens to the development of equipment for application of spray materials for control.

Prevention and Control of Forest and Range Fires, RPA 203, allows for research ranging from the physics and chemistry of combustion to prevention of lightning fires through weather modification. However, the actual research being conducted with McIntire-Stennis funds is quite limited.

A related problem area, Protection of Plants, Animals, and Man From Harmful Effects of Pollution, RPA 211, does not exclude forestry. There are examples of forest damage from air pollution which could contribute to our knowledge of pollution effects. No projects have yet been submitted under this RPA.

#### CONTROL OF INSECTS AFFECTING FORESTS

##### Research Problem Area 201

Insects exact a heavy toll of young trees each year killing many, and damaging and reducing the growth of surviving trees. Wildlife habitat is changed and fire danger is increased. Forest insect research can provide the information needed to reduce the continuing losses to forests and forest products, including Christmas trees. A sustained flow of new information provides the basis for safe, effective methods of control.

#### UNIVERSITY OF ARKANSAS, 656

Significance of *Ips* bark beetles and associated fungi causing death of pine in Arkansas.

W. C. YEARIAN and C. L. WILSON

Attention was again paid to *Ips* bark beetle activity in loblolly and shortleaf pine timber damaged by hail on April 27, 1968. Tree mortality through the first growing season averaged 38% with most of the mortality occurring in areas where the trees were more than 75% defoliated. Correlation determinations revealed a significant relationship between tree mortality and defoliation ( $r = 0.87$ ), terminal damage ( $r = 0.74$ ) and phloem damage ( $r = 0.68$ ). During the

second growing season mortality was low and did not appear to be particularly correlated with severity of damage.

*Ips calligraphus* and *Ips grandicollis* were the predominant beetle species in the area during the first growing season. In 1969 *Ips avulsus* and *Ips grandicollis* were the most common species. *Ips* populations were primarily confined to logging slash and reached peak activity in early July both seasons. *Ips* bark beetles did not appear to be significant in causing tree mortality as trees protected against *Ips* attack with insecticides died at a rate comparable to unprotected trees. In those areas where trees were heavily damaged, but still alive, *Ips* activity was limited to only the dead portions of the trees.

#### UNIVERSITY OF MAINE, 5007

##### Biology and control of the balsam gall midge.

E. A. OSGOOD and J. B. DIMOND

Additional insecticides and application methods were tested in order to prevent excessive needle drop of balsam fir. Insecticides used were: Methoxychlor, Pyrethrin, Malathion and Dimethoate. These were applied either by aircraft or by use of a backpack mounted mist blower. Timing was very important and a mist blower application of Malathion in early June when galls were first seen gave excellent results. Several trials of application before midge eggs were laid were unsuccessful.

Particular emphasis has recently been placed on the complex of hymenopterous parasites which have been found attacking (Fig. 25) the midge in the egg and larval stages. To date 6 genera and 9 species of parasites have been identified and work is continuing on this aspect with the probability that more will be added. Previously only two species of parasites were known from this host.

Ecological life history studies of the more abundant species in the genera *Tetrastichus* and *Platygaster* have been undertaken. These studies are progressing well at present and will continue. With the aid of this type of biological information, the impact of these parasites on the midge is being assessed.

#### UNIVERSITY OF MICHIGAN, 14

##### Population regulation of beetles in aspen.

F. B. KNIGHT

During 1969 life tables were prepared for both *Oberea schaumii* and *Saperda inornata* in northern Michigan. As far as possible the identification and assessment of the importance of causes for mortality and the identification of key factors was completed. These tables were based on studies of natural populations for a period of five years at six locations in the Upper Peninsula of Michigan.

*Oberea schaumii* was found to generally mature in three years in northern Michigan, though a significant portion develop in two and four years. Most egg niche failures were concentrated in the first year after oviposition. *Saperda inornata* has both a one-year and a two-year cycle in Michigan. The studies revealed that the insect has a greater potential for infestation than indicated by egg niche survey results. Again most egg niche failures occur in the first few months after oviposition. The key periods of mortality for both insects was determined to be the adult stage and the larval establishment period. The key factor is the effect of weather conditions on these vital periods in the cycles.

Field work during 1969 was mainly directed toward the key periods identified in the life table study. We were very pleased with our success in tagging adult beetles with radioactive tantalum wires in one field area. With this technique we were able to trace the activity of a small number of beetles for a four week period. These efforts will be continued during 1970 along with our continued efforts at determining the causes of mortality during the establishment period.

#### UNIVERSITY OF NEW HAMPSHIRE, 4

##### The ecology of the orbited mites and springtails of the soils of the white pine cover type in New Hampshire.

R. M. REEVES

A description and redescription of two species have been completed (Fig. 26). These include the complete chaetotaxy (numerical taxonomy) of adults and immatures. Additional descriptions of similar





Figure 25. New growth of balsam fir showing a parasite in the genus *PLATYGASTER* ovipositing in a first stage larva of the balsam gall midge. These parasites are often very abundant and take a heavy toll of eggs and first stage larvae.

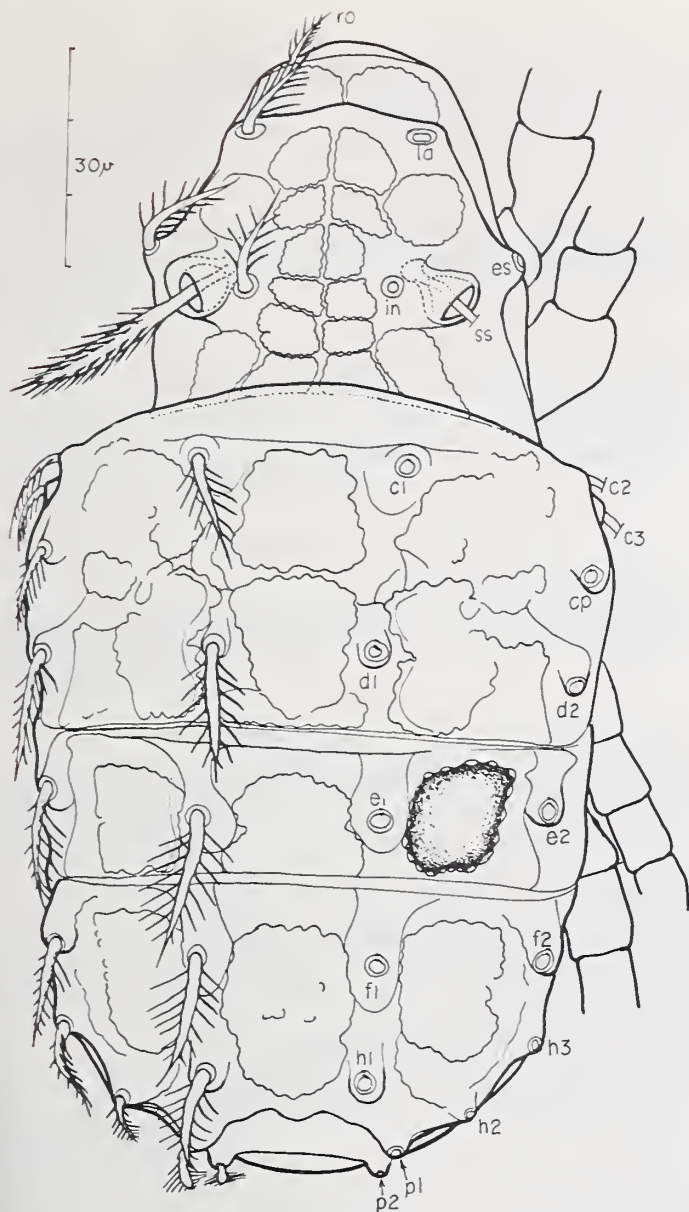


Figure 26. Dorsum of adult *Brachychthonius lydiae* (Jacot, 1938), a species redescribed more accurately by this project.

nature and content for other species are being written.

A summary of the oribatid fauna collected with the subsequent discussion of 170 oribatid species is nearing completion. Three species were found on all plots (nearly 40% of the 40,000 individuals identified), 40 more were considered common, 26 considered occasional and the remaining 101 species rare.

The relationship of mite and springtail numbers to site and stand characteristics has been partially analyzed. Application of a biomedical histogram-plot program has shown considerable variation in distribution patterns, from normal to skewed. Graphic comparisons using the same program indicate higher populations with a lower site index, a greater % pine

and less depth of horizon A. Trends were more apparent with the Trombidiformes, the Collembola, Oribatei and Mesostigmata following in that order. The Trombidiformes showed increased numbers with a decrease in understory ground and herb cover but an increase in shrub cover.

#### OREGON STATE UNIVERSITY, F-824

Biology of the Hemlock Hylesinus. W. P. NAGEL

Two species of hemlock hylesinus (*Pseudohylesinus tsugae* and *P. grandis*) threaten to become a serious problem in newly thinned stands of western hemlock (*Tsuga heterophylla*). In unthinned stands these insects have not been serious. This study of the biology of these two species has shown that they can breed only in slash, or dying material, and are not capable of killing trees under the conditions observed. Young adults of both species feed in live western hemlock prior to attacking suitable breeding material. Injury from this feeding provides entry for the hemlock bark maggot (*Cheilosia alaskensis*) into the inner bark region. The maggots do not kill trees, but cause degrade (Fig. 27) in lumber known as "black check." Adult bark beetle feeding continues for two years after pre-commercial thinnings. Trees chemically thinned with the herbicide cacodylic acid were attacked by both species of *Pseudohylesinus*, but no broods developed. Preliminary analyses indicate a possible correlation between crown closure and site quality and infestations by hemlock hylesinus and the bark maggot. As crown closure and site quality increase, insect populations decrease.

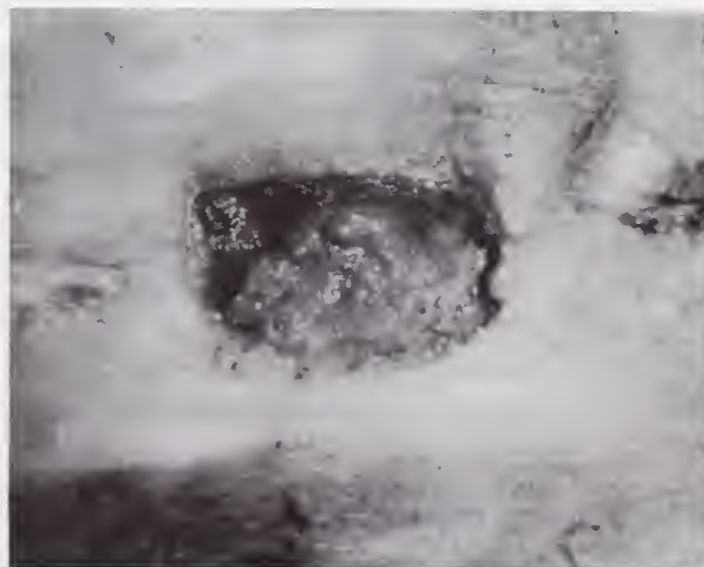


Figure 27. Internal damage caused by the hemlock bark maggot. In addition to the pitch, a lumber degrade results from a discoloration of the wood known as "black check".



## ADDITIONAL PROJECTS

### UNIVERSITY OF ARKANSAS, 611

The control of pine sawflies in Arkansas with special reference to the use of biological control agents.

L. O. WARREN and J. P. FULTON

### UNIVERSITY OF ARKANSAS, 662

Control of insects affecting seed production of loblolly and shortleaf pines in Arkansas.

W. C. YEARIAN

### COLORADO STATE UNIVERSITY, 318

Systemic insecticides in coniferous forest trees.

N. D. WYGANT and R. E. JOHNSON

### UNIVERSITY OF GEORGIA, 18

Investigations of insects affecting pine cones and seeds in the Piedmont of Georgia.

R. T. FRANKLIN

### UNIVERSITY OF IDAHO, 13

Bionomics and control of cone and seed insects.

J. A. SCHENK

### KANSAS STATE UNIVERSITY, 671

Entomology and windbreak tree species.

H. E. THOMPSON

### UNIVERSITY OF MARYLAND, H-83

Loblolly pine cone insects.

W. E. BICKLEY and F. E. WOOD

### UNIVERSITY OF MICHIGAN, 2

Comparative natural histories of three closely related beetles of the Genus *Agrilus*.

F. B. KNIGHT

### MICHIGAN STATE UNIVERSITY, 942

Autostability of arthropod component in plantation conifers.

J. A. BUTCHER

### MICHIGAN TECHNOLOGICAL UNIVERSITY, 2-3013

Basic studies of the insect transmission of sclerodermis canker.

N. F. SLOAN

### MISSISSIPPI STATE UNIVERSITY, 1129

Study of economic insects attacking certain forest tree seeds and forest seedlings.

W. W. NEEL

### UNIVERSITY OF MONTANA, 1604

Spruce budworm defoliation in Douglas-fir.

J. H. LOWE

### NEW JERSEY - RUTGERS UNIVERSITY, 436

Metabolism of insecticides by the gypsy moth.

A. J. FORGASH

### NEW MEXICO STATE UNIVERSITY, 7

Biology and host finding mechanism of the ponderosa pine cone beetle.

H. G. KINZER and J. G. WATTS

### OHIO AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER, 3

Integrated control of the insect and mite pests of pine trees.

R. L. CAMPBELL

### OKLAHOMA STATE UNIVERSITY, 1235

Bionomics, ecology, and control of the Nantucket pine tip moth.

R. D. EIKENBARY

### PENNSYLVANIA STATE UNIVERSITY, 1750

Development of the Eastern spruce gall aphid and its control.

W. H. KEARBY

### UNIVERSITY OF PUERTO RICO, 2

Biology and control of the cedar shoot-borer.

L. F. MARTORELL

### UNIVERSITY OF PUERTO RICO, 3

Ecological relationship, distribution, and control of two important species of arboreal termites.

L. F. MARTORELL

### SOUTH CAROLINA - CLEMSON UNIVERSITY, 905

The biology of pine reproduction weevils in coastal South Carolina.

R. C. FOX

### TEXAS A & M UNIVERSITY, 1525

Development of diets and rearing methods for Southern pine beetle.

P. L. ADKISSON

### UNIVERSITY OF WASHINGTON, 22

A study on the orientation of bark beetles.

R. I. GARA

### UNIVERSITY OF WISCONSIN, 1263

Population dynamics of sawflies associated with coniferous plantations.

D. M. BENJAMIN

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## CONTROL OF DISEASES, PARASITES AND NEMATODES AFFECTING FORESTS

### Research Problem Area 202

Forest disease research is essential to protect and enhance the social and economic value of trees in forests and farm woodlots. Diseases reduce the utility of trees for wildlife habitat and timber production. They kill trees, discolor foliage, retard growth, and cause decay leading to breakage and windfall. Prolonged droughts, wet periods, and changing climatic conditions accentuate tree disease problems.

### UNIVERSITY OF ARIZONA, 621

The biology and control of fungi pathogenic to forest vegetation.

R. L. GILBERTSON

The major effort on this project during this period was devoted to preparation of a manuscript on fungi associated with decay of ponderosa pine in the Southwest. This work is being done with Arthur B. Budington, graduate assistant in Plant Pathology. This will be published as a Technical Bulletin by the College of Agriculture, University of Arizona. To date, approximately 250 species of fungi have been collected from ponderosa pine and the manuscript is in rough draft form. Since ponderosa pine is the major timber species in the Southwest, this should be useful and much needed publication. The fungi



collected on ponderosa pine are being deposited in the mycological herbarium of the University of Arizona and in the National Fungus Collections at Beltsville, Maryland. Similar investigation of decay fungi on other timber species as well as on hardwoods of importance in watershed protection and in recreational areas are planned for the future. Intensive field studies of these species over the past two years has already furnished much of the needed data for these publications. The work will be continued on McIntire-Stennis project 713.

#### UNIVERSITY OF CALIFORNIA, 2383

Studies of the epidemiology and control of *Fomes Annosus* root rot. F. W. COBB

The ecology of *Fomes annosus* colonization of ponderosa pine stumps is being investigated in relation to stump temperature, exposure to solar radiation, and moisture content. The roles of other organisms, especially insects and fungi, are being studied, and several potential competitors of *F. annosus* are being evaluated (Fig. 28) for biological

control under field conditions. Initial data indicate that exposure affects stump moisture content which in turn appears to have a substantial effect upon the growth rate of *F. annosus*. However, relatively high stump temperatures are not as limiting to fungus colonization of ponderosa pine as reported for other pine species in the U.S. As yet, only the fast growing isolates of *Peniophora gigantea* seem to offer much potential in biocontrol because of the rapid rate of stump colonization by *F. annosus*. Insects may have some important indirect effects on stump ecology through their roles in transport of competing fungi and in physical modifications of the stumps.

The ecology of *F. annosus* in the soil also is being studied (Fig. 29). Laboratory tests have shown that *F. annosus* growth is stimulated through forest soils, is favored by relatively low temperatures, and that fungus growth is stimulated by greater than ambient levels of CO<sub>2</sub>. Studies have been initiated to determine the effects of nutrition and moisture tension on growth of the fungus in soil.



Figure 28. Possible biological control using fungus species antagonistic to *Fomes annosus*.





Figure 29. *Fomes annosus* growing through field soil, from grain inoculum at 15°C.

#### UNIVERSITY OF HAWAII, 721

Natural microbial antagonism in forest soils of Hawaii. WEN-HSIUNG KO

*Soil fungistasis*—Germination of conidia and ascospores of *Neurospora tetrasperma* has been tested on forest and agricultural soils of the following types: Lithosol, Regosol, Latasolic Brown Forest, and Hydrol Humic Latasol. Conidia of *N. tetrasperma* germinated completely on water agar, but failed to germinate or germinated poorly on all the soil types tested. However, ascospores of the same fungus germinated completely on the same soils indicating that, like Michigan soil, soil fungistasis in these soils may be due to nutrient deficiency.

*Phospholipase production by soil microorganisms.* Methods have been developed to enumerate and

isolate phospholipase-producing microorganisms from forest and agricultural soils. About 80% of soil actinomycetes were able to produce phospholipases, whereas only very small percentages of soil bacteria and fungi were phospholipase-producers.

#### UNIVERSITY OF MINNESOTA, 22-17

Ecology of wood decay.

D. W. FRENCH

The amount of decay in red oak caused by *Fomes robustus* was not related to the size of the cankers and the only reliable external indicator of the amount of decay was whether or not sporocarps were present; very little decay was associated with cankers lacking sporocarps. Although wounds appeared to be an important avenue of entrance for *F. robustus* in previous studies, in all 32 trees sectioned in 1969 every canker was associated with a branch. Spore dispersal was directly correlated with temperature, suggesting that infection occurs primarily during the summer months. Cankers caused by *F. robustus* were found also on ironwood (*Ostrya virginiana*), bigtooth aspen (*Populus grandidentata*), butternut (*Juglans cinerea*), red maple (*Acer rubrum*), black cherry (*Prunus serotina*) and green ash (*Fraxinus pennsylvanica* var. *lanceolata*). Preliminary studies in ash plantings in west central Minnesota indicate that *Fomes fraxinophilus* may be responsible for mortality in trees only 25 years old.

#### NORTH CAROLINA STATE UNIVERSITY, 4012

Ecology of forest tree diseases and wood deterioration. E. B. COWLING and L. F. GRAND

Achenes of sycamore contained an abundant and diverse fungus flora. Many of these fungi cause loss in germinability of achenes during storage (Fig. 30). The critical moisture content for safe storage of achenes was 10-11%. Achenes containing as much as 19% retained germinability during storage for 7 months at 2°C but achenes with as little as 13% moisture lost germinability in less than 2 months at 20 or 30°C. A technique was developed for innoculation of pines with constant numbers of basidiospores of *Cronartium fusiforme* from an uniform source at specific locations on the plants. Spores of *C. fusiforme* survived extended periods of storage without losing infectivity. Species of 20 Hymenomycetes apparently mycorrhizal with oaks





Figure 30. Effect of *Phomopsis* sp. on germination of sycamore achenes.

and pines were obtained in pure culture. Dormancy of red oak acorns was overcome by removing the pericarp and treating for 15 min. with 30%  $H_2O_2$ . This chemical is also an effective disinfectant. Preliminary data indicated no difference in numbers of ectomycorrhizae between loblolly pine and slash pine seedlings grown under hydromulch and pine straw mulch. Deterioration and death of ornamental trees and shrubs are associated with breaks in natural gas mains. Nematode populations were very low in these soils. Tests are underway to determine how gas in the soil environment might cause these biological effects.

#### UNIVERSITY OF PUERTO RICO, 1

Diseases of forest trees. J. H. LOPEZ-ROSA

The disease survey, which covered 45 species, was conducted mainly in the public forests of the Island. It revealed that most of our forest trees are free from major diseases. The most serious problem encountered was dieback and decline of *Swietenia mahagoni*, a disorder that threatens to exterminate the planted stands of this valuable species at the Susúa Forest. Other major diseases of important species were stem cankers of *Eucalyptus* spp. and *Manilkara bidentata*. *Pinus caribaea* was dying, apparently due to root rot, in a small area near the Caonillas Reservoir. Soil drainage in the area is very poor. Some other major diseases were observed on species of minor importance. *Terminalia* sp. and

*Amyris elemifera* had stem cankers, and *Inga laurina* was affected by a witches' broom. *Exostema caribaeum* was affected by what appeared to be a virus. Leaf spots of minor importance were evident on most species examined. Many fungus species, specially Deuteromycetes, were isolated from affected leaf tissues. It was demonstrated experimentally that *Phyllachora* sp. is the causal agent of tar spot, a relatively unimportant foliage disease of *S. mahagoni* (Fig. 31). The disease cycle and the life cycle of the fungus were studied under controlled conditions.

#### UNIVERSITY OF TENNESSEE, 7

Blight resistance in American chestnut. E. THOR

Of the 3000 American chestnut trees in the irradiated seed orchard only 67 trees were ten feet tall or taller. Of these, 30 trees had cankers while no cankers were present on 37 of the trees; chlorosis or dieback was noted on 38 trees. Although half of the trees larger than ten feet were 10 years old, 22 trees had reached this size in 3 years (Fig. 32). Since *Endothica parasitica* is found on almost half the trees, exposure to the disease is considered adequate for testing of resistance.

Thirty living American chestnut trees greater than 8 inches DBH have been selected in Tennessee, North





Figure 31. West Indian mahogany leaflet showing perithecia of *Phyllachora*.

Carolina and Georgia. Successful grafts from half of these trees have been established in a breeding orchard in spite of some incompatibility encountered between American chestnut scions and Chinese chestnut understock.

Bioassay of water-soluble inner bark extracts of American and Chinese chestnut were not correlated with their known resistance to *Endothia parasitica*. Thin-layer chromatographic analyses of inner bark extracts partitioned into nine fractions were inconclusive. Work has been started to improve techniques for partitioning of inner bark extracts before gas-liquid chromatographic analyses. Bioassay of the compounds identified may yield clues to the factors involved in resistance to the blight.

#### UNIVERSITY OF WYOMING, 928

Diseases of aspen in Wyoming. E. A. ANDREWS

Attempts to root budwood and leafy terminals of aspen immediately after collection and following



Figure 32. A ten year old American chestnut tree is flowering in the breeding orchard established from radiated nuts.

months of dormancy at cold temperatures failed. Sections of runner roots of aspen two inches and longer produced new shoots (Fig. 33) and roots most readily when placed in moist sand or soil immediately after being collected from growing stands. To date, no other method of obtaining increases of aspen in quantity in the greenhouse has been successful and this is absolutely essential in testing the pathogenicity of isolates of micro-organisms from diseased material collected in the field. While the process is still laborious and time consuming, it is economically feasible as a recourse while continuing efforts to root budwood in the usual manner.





Figure 33. Young aspen started from 2-inch sections of root.

Subsequent pathogenicity tests using the above greenhouse grown seedlings and spores of *Cytospora* sp. from nutrient cultures and from spore horns that developed on aspen branches collected in the field have as yet produced no infections. Fertilizing the seedlings with nutrient solutions that varied in phosphorous content resulted initially in more blackened leaves on those plants receiving the low concentrations of phosphorous. Soon afterward, all treatments appeared alike. Tests of soil taken from many of the collection locations throughout the state indicated no correlation with the disease severity observed in the aspen stands at the corresponding locations.

### ADDITIONAL PROJECTS

#### ALABAMA - AUBURN UNIVERSITY, 907

Fungal pathogens associated with littleleaf and seedling diseases of Southern pines. W. D. KELLEY

#### ALABAMA - AUBURN UNIVERSITY, 911

Ingression of *Hypoxylon* into Southern oaks. T. C. DAVIS

#### UNIVERSITY OF ARIZONA, 713

Diseases and decay of woody plants on Arizona watersheds and recreational areas.

R. L. GILBERTSON

#### UNIVERSITY OF ARKANSAS, 663

Organelles of fungi causing forest-tree diseases.

C. L. WILSON

#### UNIVERSITY OF CALIFORNIA, 2348

Microbiology and Pathology of Wetwood in California firs. W. W. WILCOX

#### UNIVERSITY OF FLORIDA, 1320

Fusiform rust resistance in slash pine.

R. A. SCHMIDT

#### UNIVERSITY OF FLORIDA, 1446

Epidemiology of fusiform rust. R. A. SCHMIDT

#### UNIVERSITY OF HAWAII, 715

The ecology of *Phytophthora cinnamomi* in forest soils. E. E. TRUJILLO and A. H. McCAIN

#### UNIVERSITY OF IDAHO, 11

Decay of inland-northwestern timber trees.

A. D. PARTRIDGE

#### LOUISIANA POLYTECHNIC INSTITUTE, 5

The morphology and cytology of the pine-oak gall rusts in the South and the relationship with their coniferous and angiospermous hosts.

F. F. JEWELL

#### LOUISIANA POLYTECHNIC INSTITUTE, MRP-51

The cultivation of *Cronartium Fusiforme* on selective artificial media. F. F. JEWELL

#### UNIVERSITY OF MARYLAND, J-101

Forest tree seedlings and soil fungi relationships.

W. L. KLARMAN

#### UNIVERSITY OF MASSACHUSETTS, 1

Etiology of maple tree decline in Massachusetts.

W. M. BANFIELD

#### UNIVERSITY OF MICHIGAN, 15

Isolation of microorganisms from preservative-treated wood and effect on wood preservatives.

H. L. MORTON

#### UNIVERSITY OF MINNESOTA, 22-18

Dwarfmistletoe. D. W. FRENCH, M. P. MEYER and F. D. IRVING

OREGON STATE UNIVERSITY, F-819  
Phytophyhora root rot. L. F. ROTH

PENNSYLVANIA STATE UNIVERSITY, 1702  
Epidemiology of forest tree diseases. F. A. WOOD

PENNSYLVANIA STATE UNIVERSITY, 1825  
An annual canker of maple.  
W. W. WARD, F. A. WOOD  
and T. W. BOWERSOX

TEXAS A & M UNIVERSITY, 1526  
Etiology and control of live oak decline.  
E. P. VAN ARSDEL

UNIVERSITY OF WASHINGTON, 8  
Fomes Annosus under stand management in North-  
west. C. H. DRIVER

WASHINGTON STATE UNIVERSITY, 1770  
Development and pathogenicity of hypoxylon  
fuscum in NW species of alder. J. D. ROGERS

UNIVERSITY OF WISCONSIN, 1264  
Oak wilt: Its development, spread and control.  
J. E. KUNTZ

UNIVERSITY OF WISCONSIN, 1434  
Etiology, epidemiology, and control of forest planta-  
tion root diseases. R. F. PATTON

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## PREVENTION AND CONTROL OF FOREST AND RANGE FIRES

### Research Problem Area 203

Fire research develops the knowledge for safeguarding more than one billion acres of public and private forest and range lands. Fires create air and water pollution, damage outdoor recreation, destroy natural beauty, injure natural resource-based industries, sweep rural communities and even cities, and take human lives. More than 150,000 forest fires occur annually. Development of new fire prevention methods to reduce the number of fires, new technology for fuel hazard reduction, and improved systems for fire detection and effective attack on threatening fires is needed.

### UNIVERSITY OF CALIFORNIA - BERKELEY, 2351

Relation of composition and distribution of vegetation to fuels on wildlands. A. M. SCHULTZ

The objective was to see how vegetation distribution and diversity are related to fuels. Pattern was studied in annual grassland, oak savanna, chamise chaparral, pygmy forest, and mixed conifer forest. The diversity of pattern or "mixed-ness" of species showed highest information values for grassland, lowest in chaparral. When, instead of species, fuel types were measured, information content dropped drastically. This was due to the similarity between species for such characteristics as calorie value, kindling point, ignitability, fuel structure, growth form of plants, carbon content, and moisture content. Thus, the information content of a stand of annual grasses and a pure stand of chamise can be similar, while fuel characteristics are quite different. Moreover, within stands, species composition might vary widely, while fuel diversity is low. It was concluded that this approach to the study of fuel hazards was unfruitful and therefore the project was discontinued.

## Chapter 5

### FOREST MENSURATION

Measurements of the living forest and products are essential to evaluate the amount of growth occurring or to determine how much has been removed from the stand. Thus, mensuration research is a special type of mathematics mainly concerned with volume of wood. However, several other topics are listed under this heading of the Oxford System. These include assessment of site quality, age determination, stand density, survey, and mapping.

Appraisal of Forest and Range Resources, RPA 110, under which the forest survey research is classified, includes a smaller group of subjects than most RPA's. This is partially due to the creation of RPA 113, Remote Sensing, much of which was previously considered to be part of 110. With the coming of opportunity for developing new and very powerful tools for information gathering systems provided by the space program, a new field of technology has been born. Although there are technical problems still to be solved in remote sensing, this is really more of an "Opportunity area" than a "problem area."

The bulk of the research in mensuration actually is best classified as part of RPA 111, Biology, Culture, and Management of Forests and Timber-Related Crops.

#### APPRAISAL OF FOREST AND RANGE RESOURCES

##### Research Problem Area 110

Periodic appraisals of forest and range resources of the nation are essential to determine the adequacy of public conservation policies and programs and to guide the development of private forest and range enterprises.

The timber resources of the nation, including some 500 million acres of commercial forest land, vary greatly in productivity and availability for industrial use. They show widely divergent trends in growth, depletion and quality. The increasing use of resource data to evaluate future needs for Federal and State forestry programs and to provide guidance for the continuing expansion of wood-using industries in

various regions makes it imperative that appraisals of timber resources be intensified and kept up to date.

The range resources of the Nation vary widely in productivity, condition, and potential importance for sustaining livestock and wildlife. There is growing need for a comprehensive appraisal of range conditions and opportunities for improving capacity and use to meet future demands for livestock forage, for water yield and for wildlife habitat.

##### ALABAMA - AUBURN UNIVERSITY, 909

**Standardized forest condition classes for aerial forest inventory.**  
**E. W. JOHNSON**

Work has been done on the development of a set of standardized texture categories for describing the appearance of forest condition classes on aerial photos. Photographs have been taken of a wide



variety of surfaces including various grades of sandpaper, types of textiles, rugs, etc. Work is being done to organize these into a coherent system.

The development of an ecological framework for the classification of forest stands in the Ridge and Valley Province of Alabama has been initiated.

#### UNIVERSITY OF CALIFORNIA, 2350

##### Methods of estimating long-range timber supply.

H. A. VAUX

Using costs and yields from the U.S. Forest Service's "Douglas-fir Supply Study," we estimated a narrow range of the long-run marginal cost curve for Douglas-fir Region stumpage on National Forests. Past supply responses showed that the National Forest component of supply was the principal potential source for expanded Regional output during the next 3 decades. We then estimated potential future effects on regional Douglas-fir stumpage prices of alternative supply policies which might be applied to the National Forests. We concluded that: both the efficiency of timber-growing and the sustained yield output of National Forests could be increased by adopting more intensive management methods than those presented in "The Douglas-fir Supply Study"; shortening National Forest rotations by 30 years may decrease the long-run efficiency of timber-growing, rather than increase it; the existing old-growth surplus on Douglas-fir Region National Forests could be managed to reduce significantly the rising trend of stumpage prices.

The North Coast Subregion Supply Simulator was used to analyze prospective timber supply in Humboldt County. We conclude that levels of redwood harvest in the County appear sustainable for the future, but that harvest of other species from private land faces imminent drastic decline. If appropriate forest management policies are adopted now, the level of total harvest in the County may be sustainable at about 3/4 of the present level.

#### OREGON STATE UNIVERSITY, F-823

##### Effect of spatial distribution on sample variance.

D. P. PAINE

Systematic and random sampling designs are used in the measurement of forests, with each having certain advantages. The relative efficiency of the two systems was determined by a comparison of sample mean

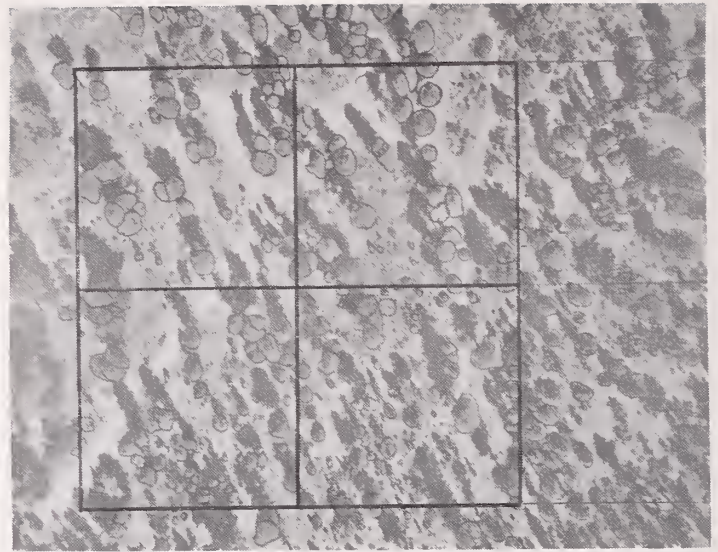


Figure 34. Aerial photographs were used to determine the crown areas and tree frequencies on sample plots. Tree position (by grid coordinates) and crown dimensions were placed in a computer to permit exhaustive sampling. The clumpiness of tree populations is evident.

variances of crown area and tree frequency. The basic data consisted of crown maps of five different major timber types of 48 acres each. Tree position (by grid coordinates) and crown dimensions (Fig. 34) were stored in the memory of a computer. Each type was exhaustively sampled both randomly and systematically by the computer. The spatial distribution of the trees in each stand was rearranged five different ways and resampled to give variance estimates over a wide range of spatial distributions. Eight different measures of randomness were compared with the "random point to nearest neighbor" method being selected as best.

When sampling from randomly distributed populations, there was no difference in efficiency between the two systems. However for uniform populations, random sampling was from 15 to 79 percent more efficient, and for clumped populations, systematic sampling was from 10 to 179 percent more efficient. The correlation between relative efficiency of systematic as compared to random sampling and the coefficient of randomization for tree frequency was relatively high and not significantly different for four of the populations. These data were combined in a regression equation of relative efficiency over the coefficient of randomization.

A quantitative knowledge of this relationship can be used to adjust variance, and therefore sample size, when using a systematic sampling design to sample for the number of trees per acre. Since most stands are clumped this means a reduction in sample size at a reduced cost with no loss in precision.

## ADDITIONAL PROJECTS

### UNIVERSITY OF ARIZONA, 662

Development of volume tables for ponderosa pine from aerial photos. G. S. LEHMAN

### NORTHERN ARIZONA UNIVERSITY, NAU-07

Aerial surveys of land and timber resources. T. E. AVERY

### COLORADO STATE UNIVERSITY, 323

Evaluation of timber supply forecasting methods. W. E. FRAYER

### COLORADO STATE UNIVERSITY, 324

Classification of complex resource systems. W. H. MOIR

### CONNECTICUT - NEW HAVEN, 414

Multivariate analysis of permanent plot data in hardwood forest. P. E. WAGGONER and G. R. STEPHENS

### UNIVERSITY OF MASSACHUSETTS, 8

Aerial photographs to evaluate the recreational resources of a river. W. P. MacCONNELL

### UNIVERSITY OF MONTANA, 1610

Photo-interpretation of the forest industry. W. R. PIERCE

### NEW YORK - STATE UNIV. COLLEGE OF FORESTRY AT SYRACUSE UNIVERSITY, 110-0-8

Forest sampling. C. A. BICKFORD

### OKLAHOMA STATE UNIVERSITY, 1247

Tree distribution by major forest types of the United States. N. WALKER

### UTAH STATE UNIVERSITY, 757

Conifer distribution in the Great Basin and adjacent mountains. R. M. LANNER

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### MacCONNELL, W. P. and W. E. ARCHEY.

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### MacCONNELL, W. P. and G. P. STOLL.

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### WENSEL, L. C. and H. H. JOHN.

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# BIOLOGY, CULTURE, AND MANAGEMENT OF FORESTS AND TIMBER-RELATED CROPS

## Research Problem Area 111

Culture and management are directed at producing adequate supplies at reasonable cost, by methods that harmonize with other forest uses. For the 40 important commercial timber types in the United States, it is necessary to develop techniques for intensive culture on the most accessible and productive sites; and methods for combining timber culture with other uses on the remaining sites. The major job is to find out how to convert wild forests to managed forests of better species, higher quality, and faster growth in the shortest time and at least cost. Each type, including Christmas trees, has distinctive silvicultural characteristics. Research devises improved cultural techniques for the more than 130 commercial timber species, and better methods for forecasting growth and quality changes in relation to management practices, thus providing the basis for selection of economic alternatives.

**UNIVERSITY OF VERMONT, 4**  
**Volume equations for major forest trees.**

**C. C. MYERS**

A multiple regression predicting equation for total cubic foot volume of sugar maple, developed as a Master's thesis, was tested against volumes obtained from xylometer readings (Fig. 35). The predicting equation was based on volumes computed by Smalian's formula from a sample of 253 trees located throughout Vermont. Results indicate that unless a 1-in-20 chance has occurred, the predicted volume will not be within a specified accuracy of one cubic foot of the measured volume. Indications are that existing volume equations, specifically the composite equations developed by Gevorkiantz and Olsen for timber in the Lake States will be satisfactory for Vermont. Tests to determine their applicability are being considered.

## ADDITIONAL PROJECTS

**NORTHERN ARIZONA UNIVERSITY, 3**  
**Past vegetation and climates of ponderosa pine zone in Northern Arizona.**  
**D. W. BERRY**



Figure 35. Submersing sugar maple to obtain volume by displacement.

**UNIVERSITY OF CALIFORNIA - Berkeley, 2520**  
**Mathematical simulation of forest stands.**

**L. C. WENSEL**

**CALIFORNIA - HUMBOLDT STATE COLLEGE, 17**  
**Vegetation habitat types of the Salmon Mountains, Northwest California.**  
**D. A. THORNBURGH**

**UNIVERSITY OF GEORGIA, 21**  
**Prediction of growth and yield of loblolly and slash pine plantations.**  
**J. L. CLUTTER**

**SOUTHERN ILLINOIS UNIVERSITY, 4-67**  
**Dendrochronology of shortleaf pine.** **W. C. ASHBY**

**INDIANA - PURDUE UNIVERSITY, 1586**  
**Data processing for small woodland management.**  
**J. W. MOSER, JR.**

**MICHIGAN TECHNOLOGICAL UNIVERSITY, 3012**  
**Development of a standardized program for automatic data processing of forest measurement records.**  
**J. W. METEER**



**UNIVERSITY OF MINNESOTA, 19-38**

Application of computer technology and o.r. techniques to forest inventory and management.

H. H. JOHN

**NORTH CAROLINA STATE UNIVERSITY, 4014**

Estimation of parameters in non-linear models of tree growth.

W. L. HAFLEY

**OREGON STATE UNIVERSITY, F-822**

Tree volume by height accumulation.

D. P. PAINE

**OREGON STATE UNIVERSITY, F-841**

Three-P sampling and optical dendrometer for cubic-foot growth on forest areas.

J. F. BELL

**OREGON STATE UNIVERSITY, F-843**

Prediction of growth and yield of young-growth Douglas-fir stands.

D. P. PAINE

**TEXAS A & M UNIVERSITY, 1761**

Growth and yield of pine plantations in East Texas.

D. M. MOEHRING, R. G. MERRIFIELD

## **PUBLICATIONS**

**ESTES, H.**

Dendrochronology of three tree species in the Central Mississippi Valley. Ph.D. Dissertation. South. Ill. Univ. 1969.

**MOSER, JOHN W. JR. and THOMAS W. BEERS.**

Parameter Estimation in nonlinear volume equations. Jour. of For. 67(12) 878-879. 1969.

## **REMOTE SENSING**

### **Research Problem Area 113**

Programs in agriculture and in agricultural development are heavily dependent on having timely information for decision-making. Opportunities for increasing and sustaining the productivity of natural resources and for facilitating product flows in agriculture are dependent on accurate, comprehensive, and timely information on resource use, availability, productivity potential, and other characteristics. The paucity of such information is a major obstacle in the economic development of the undeveloped regions of the world and a significant obstacle to the formula-

tion of important policies and programs in the more fully developed regions.

Generally such information on natural resources has been obtained from ground surveys. These surveys are costly, and in the more remote and inaccessible regions of the world, they are difficult, if not impossible, to make.

The space age offers new, potentially powerful tools for use in the development of information gathering systems. Ways to exploit the advantages of earth-orbiting spacecraft in acquiring many types of data need to be explored.

**NEW YORK (CORNELL) UNIV., 906**

Classification of rural lands based on remote sensor surveys.

L. S. HAMILTON, E. E. HARDY

Mr. Bailey pursued research on assessing the value of standard 1:20,000 scale panchromatic air photos as a tool in land use planning. Field trips in the area of Cayuga County (the selected study area) were undertaken, and site selection and analysis started. Work is designed to develop a biological and physiographic classification based on aerial photographic interpretation for resource based outdoor recreation. Existing classifications have been reviewed, and information pertinent to this study extracted. A suitable vegetative classification has been developed and tested on 1:20,000 and 1:24,000 scale air photos. A ground reconnaissance of the study area and its major features has been partially completed. Contacts have been made with key resource personnel in the study area, and the County Plan has been reviewed, particularly in relation to resource based outdoor recreation facilities.

Mr. Kasvinsky initiated research work in July on work "Assessing the Utility of Remote Sensing Survey for Water Quality Control Planning." The research includes an analysis of present and potential water pollution susceptibility in the Fall Creek drainage basin. Research objectives have been established, pertinent literature has been reviewed and the plan for research procedures has been fully developed.

General progress on finding new uses for airphotos as a means of analyzing land resources continues with many productive developments.



## ADDITIONAL PROJECTS

UNIVERSITY OF CALIFORNIA, 2180

Multiband spectral reconnaissance for forestry.

R. N. COLWELL

## PUBLICATIONS

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Development of a land use classification system based on interpretation of imagery from the Earth resources technology satellite. Center for Aerial Photographic Studies, Cornell Univ. 1969.

CAYLOR, J. A., G. A. THORLEY and R. N. COLWELL.

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National Park". A report under USDI NPS Contract 14-10-4; 102-030. 22 pages. Illustrated. Univ. of Calif. (31 Dec 1968).

HARDY, E. E.

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Potential benefits to be derived from applications of remote sensing of agricultural, forest and range resources. Minutes of annual American Astronautical Society national meeting. Las Cruces, New Mexico. Oct. 1969.

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"Remote Sensing for Brush Species Identification Using Multispectral Techniques". 75 pp. Univ. of Calif. (March, 1969).

## Chapter 6

# FOREST MANAGEMENT

Systems analysis is one of the decision making tools and is used to determine the most efficient combinations of timber production practices. Policy and program effects can also be evaluated using this procedure. Model building and other optimization techniques have been adapted for use in forest management practices.

RPA 303 is concerned primarily with the economics of timber production and forestry investments decision making.

### ECONOMICS OF TIMBER PRODUCTION

#### Research Problem Area 303

Timber production efficiency research investigates how income can be increased through effective use of labor and capital. Such information is generally lacking for the wide variety of forestry investments possible in different areas. Returns of expenditures for planting, stand improvement, and other timber growing activities vary widely throughout the nation and depend on many cost factors including the quantity and quality of timber yields, and local market conditions. Identifying the most profitable opportunities for management of public forestry programs and for private investments on forest lands is basic to efficient allocation of the funds available for timber growing.

#### NORTH CAROLINA STATE UNIVERSITY, 4021

A study of computer simulation and its potential benefit.

A. G. MULLIN, W. KEPPLER, JR.,  
and D. PHILLIPS

Simulating current policies and operating conditions can be an effective managerial tool. This was demonstrated for the North Carolina Forest Service by simulating the airplane bombing operations on forest fires. A simulation model was developed using actual

data on forest fire occurrence and airplane operating characteristics. Under the conditions given, a single airplane would have had an average utilization of 25% during the daylight hours, and would have bombed as many as five fires in a single day as shown in Figure 36. The simulation also showed that 5% of the fires were not bombed because the airplane was on bombing operations when the fire started, and

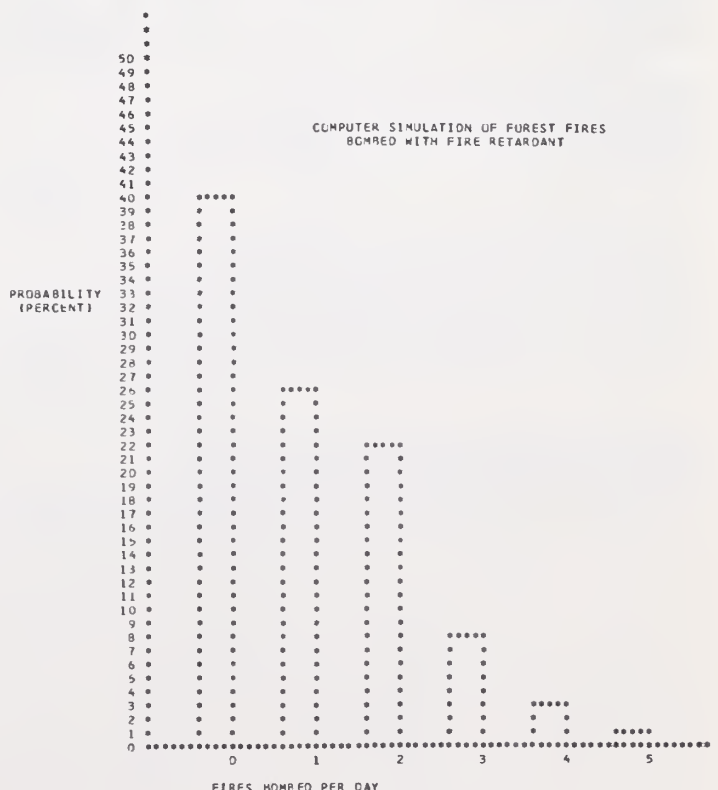


Figure 36



remained busy until dark. This model could be used to help answer such questions as: What would be the results of adding another airplane?, or How much fire retardant should be kept in inventory?

Another simulation model was developed describing the operation of a southern pine plywood plant from the log pile through the lathe. During the coming year we will extend this study to include the complete plywood plant operation.

### ADDITIONAL PROJECTS

UNIVERSITY OF CALIFORNIA - BERKELEY,  
2349

Determination of optimum forest production schedules by mathematical programming.

D. E. TEEGUARDEN

UNIVERSITY OF CALIFORNIA - BERKELEY,  
2447

Financially optimum thinning regimes for mixed-conifer forests of California.

R. F. GRAH

UNIVERSITY OF GEORGIA, 19

Cash flow and forest management policy as related to income and taxes.

J. L. CLUTTER

MICHIGAN STATE UNIVERSITY, 978

Financial evaluation of forest management opportunities.

V. J. RUDOLPH

UNIVERSITY OF MISSOURI, 543

Financial aspects of silvicultural practices.

R. C. SMITH

UNIVERSITY OF NEW HAMPSHIRE, 2

Application of mathematical programming models to planning over time in the large forest firm.

B. B. FOSTER

OREGON STATE UNIVERSITY, F-833

The economics of chemical brush control.

C. F. SUTHERLAND

SOUTH CAROLINA - CLEMSON UNIVERSITY,  
707

Logging cost studies.

W. A. SHAIN

UNIVERSITY OF TENNESSEE, 10

Economics of alternative timber-growing practices in Tennessee hardwood stands.

G. R. WELLS

UNIVERSITY OF VERMONT, 14

Forest management by parametric linear programming.

F. ARMSTRONG

UNIVERSITY OF WASHINGTON, 7

Timber harvesting in Pacific Northwest second growth stands.

G. STENZEL

UNIVERSITY OF WISCONSIN, 1571

Computer simulation of sampling designs and management practices in forestry.

L. G. ARVANITIS

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## Chapter 7

# MARKETING OF FOREST PRODUCTS

Economics of forest transport and of the forest products industries along with the quantitative aspect of marketing—demand and supply—are to be found in this chapter. That prime result of the marketing situation—price—should be located in this subject-area. Trade customs, trade policy, and marketing administration round out the major potential contents of Chapter VII.

Progress reports of two Research Problem areas; 502, Development of Markets and Efficient Marketing of Timber and Related Products and 513, Supply, Demand, Price of Forest Products are located in Chapter VII.

### DEVELOPMENT OF MARKETS AND EFFICIENT MARKETING OF TIMBER AND RELATED PRODUCTS

#### Research Problem Area 502

Development of markets and efficient marketing of timber and related products may help to maintain the incomes and employment associated with the timber industry. Non-wood products have penetrated many traditional markets for wood materials in construction, manufacturing, shipping, and other uses. Research to evaluate opportunities for market expansion through more efficient processing and marketing of timber products is essential to maintain and improve the competitive position of wood, and wood and timber related products.

#### UNIVERSITY OF CALIFORNIA, 2538

Economic analysis of wood procurement systems.

W. McKILLOP

Work on this project was temporarily discontinued while the project leader was on sabbatical leave during the latter part of 1969. In the earlier part of 1969, theoretical models dealing with the economics of logging and log allocation were constructed. Field

work could not be carried out because of lack of personnel.

#### LOUISIANA STATE UNIVERSITY, 1233

Lumber distribution patterns in Louisiana.

P. J. FOGG

This project was terminated during 1969. Analysis of data collected from nearly all active sawmills and approximately two-thirds of the lumber wholesalers in Louisiana was completed. Louisiana is a net exporter of lumber. This pattern is predominantly determined by the export by sawmills of approximately 60 percent of their cut. Pine was exported mainly to the adjoining states (85 percent of the pine exports), whereas hardwood was exported mainly to more distant states (59 percent of the hardwood exports). Of all these exports, approximately one-half were pine and one-half were hardwood. Lumber wholesalers, however, were net importers of lumber, and were found to import about 57 percent of their needs, while making 74 percent of their sales in Louisiana. The wholesalers imported about one-third of their hardwood needs, and about two-thirds of their pine needs. The combined effect of the activities of the sawmills and wholesalers resulted in an estimated export of as much lumber as is used within the state. Most of the sales of lumber by sawmills



within the state do not pass through the hands of wholesalers, as many of the sales are direct to the retailers. The most common problem experienced by sawmills was that of obtaining sufficient logs, while that of the wholesalers was that of obtaining what they termed "Quality Material". The hardwood mills appeared to experience fewer marketing problems than the pine mills.

## ADDITIONAL PROJECTS

### UNIVERSITY OF ALASKA, 270-7501

An analysis of the opportunities for integrated forest utilization in rainbelt area of Alaska. M. R. MASSIE

### UNIVERSITY OF IDAHO, 6

Potential markets for cut-up lumber stock.

E. L. WILLIAMS

### UNIVERSITY OF ILLINOIS, 310

A survey of secondary wood-using industries.

I. I. HOLLAND

### UNIVERSITY OF MARYLAND, A-26

Forest market structure.

R. F. McDONALD

### UNIVERSITY OF MONTANA, 202

Marketing Montana lumber.

R. W. WAMBACH

### NORTH CAROLINA STATE UNIVERSITY, 4022

Wood residue production and feasibility of saleable product. D. H. J. STEENSEN, W. E. KEPPLER, JR.

### TEXAS A & M UNIVERSITY, 1524

Requirements and distribution of wood products manufactured and used in Texas. H. B. SORENSON

### UTAH STATE UNIVERSITY, 767

Efficiency of lumber manufacture in Utah.

A. B. FURNISS

### UNIVERSITY OF WISCONSIN, 1364

Technological change in forest industries.

W. R. BENTLEY

## PUBLICATIONS

### McDONALD, R. F. and D. W. THATCH.

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### ROSS, S., H. D. SMITH, and R. F. McDONALD.

An analysis of the role of woodlot owners in the marketing structure for timber in Maryland, Misc. Pub. 717, Univ. of Maryland Ag. Exp. Sta. (August 1969).

### SORENSEN, H. B. and J. D. McNEASE.

"Wholesale Marketing of Texas Lumber," Texas A & M Univ. Dep. of Agr. Econ. and Soc. Dept. Infor. Report No. 69-5, 1969.

## SUPPLY, DEMAND, AND PRICE ANALYSIS—FOREST PRODUCTS

### Research Problem Area 513

Improved forecasts of supply, demand, and prices of forest products are essential to more efficient and orderly planning for production and marketing. Individual producers, processing and marketing firms, and end users base decisions upon information about the forecasts of future supply, demand and price conditions. Sound public policy of forest conservation is dependent upon such information. The forest supply industries need similar data on goods and services purchased by producers so that they may make orderly adjustments to prospective changes in supply demand and price of production inputs.

### UNIVERSITY OF CALIFORNIA, 2505

The role of oligopsony and monopoly in markets for publicly owned timber in California. H. J. VAUX

The Central Sierra timber market area showed distinctly different structure from the South Sierra market area during the 1957-66 study period. The individual market units, or timbersheds, were 50 percent larger in the Central Sierra than in the South Sierra, reflecting less severe topography and better-developed primary roads. Only one of the three market units in the Central Sierra was dominated by a single buyer; in the other two units, several buyers maintained substantial positions in the stumpage market throughout the period of analysis. As a result, the general level of competition for timber sales and of overbidding on sales was significantly higher in the Central Sierra than in the South. The earlier finding from the South Sierra that sales with heavy proportions of pine were overbid more than sales with small proportions of pine was confirmed. In large sales, overbidding was concentrated in a few sales with 90% of the overbid in only 26% of the sales.

**KANSAS STATE UNIVERSITY, 670****Marketing of forest products.****W. A. GEYER**

The outlook for forestry in Kansas is favorable. The potential for manufacturing forest products is not yet fully developed. Primary processors in and immediately adjacent to Kansas are expanding their operations to take advantage of improved markets for the high-quality sawtimber produced. There is a real need and opportunity for secondary processors to utilize the lumber being manufactured. The state also needs more forest products industries that can use small and low-quality material. The development of more of these industries, such as pulpmills, charcoal plants, and pallet manufactures, would allow a more effective and complete utilization of Kansas timber resources.

**NEW MEXICO STATE UNIVERSITY, 6****Economic feasibility of a particleboard industry in New Mexico.****J. R. GRAY**

With 260,000 tons of coarse residues and planer shavings being produced annually in New Mexico and southern Colorado, sufficient raw materials are available to support seven 100-ton-per-day particleboard plants or ten 75-ton plants in New Mexico. If small roundwood supplies are added, plant numbers could be increased to 13, 100-ton or 17, 75-ton plants. A particleboard plant in New Mexico would require an investment of approximately \$2,513,000 for a 100-ton plant and \$2,255,000 for a 75-ton plant. Cost and return analysis indicated the return on investments for two sizes of plants in 17 locations in New Mexico using sawmill residues exclusively would vary from 4.3 to 6.8 percent on the smaller plant investment and 8.1 to 10.7 percent on the larger plant investment, depending on location. The Southwestern market for particleboard in 1966 was an estimated 52 million square feet, 3/4 inch basis. Statistical projections indicated the demand will increase over twice the 1966 level by 1975, and over five times the 1966 level by 1985. With completion of early phases of the project (marketing of finished product and supply of raw materials), a decision was made by a cooperating forest products firm in New Mexico to construct at least one plant in the state.

**ADDITIONAL PROJECTS****UNIVERSITY OF ALASKA, 3****The Alaska market for softwood lumber.****R. SNYDER, M. R. C. MASSIE****NEW MEXICO STATE UNIVERSITY, 8****Economic analysis of market opportunities for New Mexico forest mill by-products.****J. R. GRAY****VIRGINIA POLYTECHNIC INSTITUTE, 636118****Efficiency of decision making: forest management.****E. F. THOMPSON****UNIVERSITY OF WASHINGTON, 19****Structural change in the forest products industries of the Pacific Northwest.****T. WAGGENER****PUBLICATIONS****CURTIS, C. W.**

Particleboard demand analysis and projections in the Southwest. M.S. thesis, New Mexico State Univ. 1968.

**SIMPSON, M. L., JR.**

A computer simulation model for use in considering alternative wood procurement policies. M.S. Thesis, Va. Poly. Inst. 1969.

**THOMPSON, E. F.**

Compounding and discounting factors for forest management decisions. Va. Poly. Inst., Res. Div. Report 127. 57 p. 1969.

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Linear programming over time to establish least-cost wood procurement schedules. Va. Poly. Inst., Res. Div. Bull. 29. 70 p. 1969.

**THOMPSON, E. F. and D. P. RICHARDS.**

Forestry practice in a changing economy. For. Farmer 28(5):16-17, 25. 1969.

**THOMPSON, E. F. and D. P. RICHARDS.**

Using linear programming to develop long-term, least-cost wood procurement schedules. Pulp and Paper Mag. of Can. 70(c):172-175. 1969.



## Chapter 8

# FOREST PRODUCTS AND THEIR UTILIZATION

Starting with the anatomical elements and tissues of wood and bark for structure and identification, the topics in Chapter VIII progress into physical and mechanical properties, then wood chemistry. Conversion, shaping, assembly, and finishing of wood are next treated, followed by uses of wood as various products from fuelwood to veneer, and on to wood flour. Preservation, grading, pulping are duely considered, as are the many minor forest products including bark products, Christmas trees, resins and turpentine, maple sugar, and others.

Reports of research in New and Improved Forest Products, RPA 401, Grades and Standards of Forest Products, RPA 512, Housing for Rural Families, RPA 801, and RPA 901, Alleviate Soil, Water, and Air Pollution are presented in this Chapter. Accomplishments in these areas are of great importance to the nation.

### NEW AND IMPROVED FOREST PRODUCTS

#### Research Problem Area 401

The objectives of forest products research are to develop (1) lower cost products with greater desirability, serviceability, and performance, and (2) greater use of low-quality timber, little-used species, and materials now remaining as waste.

There is a continuing decline in quality of available timber because of the lack of adequate replacements for the larger and better quality trees. Demand for timber products is expected to go up 80 percent by the year 2000. Research is needed to develop ways to convert more low-grade material into useful products. Where such timber is abundant it may be possible to establish new industries and enhance economic growth. Improved wood utilization also provides a profitable means for upgrading residual stands. Use of low-quality trees frees space for better growing stock.

### COLORADO STATE UNIVERSITY, 314 Particle board from Colorado species.

A. B. ANDERSON

Characteristics of Engelmann spruce and lodgepole pine have been evaluated for their suitability as particleboard species. Results show that no serious technical problems should arise due to peculiar species characteristics. The light color, the relative low density of the wood and the ease of furnish preparation are attributes favoring these species.

In addition to assessing the species effect on board properties, particle size, effect of presstime, thickness-density within a panel, density distribution, moisture content of furnish, resin content, heat transfer, permeability and spring back were the major factors correlated to the physical and mechanical properties.

Much of the data collected from over 1,000 study panels is available for publication. These data

establish important parameters and are indicative of the suitability of Engelmann spruce and lodgepole pine as a particleboard raw material.

Publications are now in the process of being prepared to make data available.

#### UNIVERSITY OF ILLINOIS, 334

##### Penta-treatment and strength of Douglas-fir.

C. S. WALTERS

The study is designed to determine what effects solution pressure, when accompanied by changes in solution temperature and wood moisture content, has on the stiffness and bending strength of Douglas-fir, and on the amount of solution absorbed by the wood.

Specimens at 6.7 and 28 percent moisture content were treated at 0 (atmospheric), 100, 200, 400, and 800 psig in solutions heated to 100° F. and 200° F. Results of static bending tests were reported in 1968. Highest solution absorption, 33.72 pounds/cu.ft. (pcf), was obtained when the wood with 6.7 percent moisture content was treated at 800 psig in a solution heated to 200° F. It was concluded that seasoning wood to the fiber-saturation point (perhaps 28 percent), or slightly below it, treating it in 200° solution at 200 psig Lowry pressure gave optimum absorption, approximately 8 pcf. When the wood was heated to 200° F., collapse of wood cells occurred in dry (6.7 percent moisture) as well as green (28 percent moisture) wood when treated at a pressure of 400 psig or more. If the wood was green, it collapsed under pressures as low as 400 psig if the wood was heated to 100° F. Three, Class 3, incised, red gum crossties (one cylinder load) absorbed from 14.9 pcf to 15.7 pcf, averaging 15.2 pcf when treated at 800 psig for 30 minutes at 205° F. The maximum difference between the absorption predicted by the equation developed in the first phase of the study,  $Y = 0.01753X + 0.523$ , and actual absorptions was 1.2 pcf. No deleterious effects were observed.

A study of the conditions causing collapse was initiated. A strain indicator was made that monitors changes in the radial and tangential dimensions of the specimen over time and while the specimen is undergoing pressure treatment (Figure 37). About a fourth of the 64 specimens have been treated on schedules similar to the original factors of design.

#### UNIVERSITY OF MAINE, 5003

##### Density and seasoning of plantation-grown red pine.

G. BAKER and N. P. KUTSCHA

It was determined that average tree density can be satisfactorily predicted from increment cores collected at breast height in immature red pine (*Pinus resinosa*, Ait.) plantations. The test was made in a 25-year old plantation in which there were blocks of trees planted at spacings ranging from 2 feet to 10 feet. Based on the two extremes of spacing, significant differences in tree density were noted. In the 2-foot spacing the pattern of specific gravity variation within the trees showed a decrease in density with height above ground, characteristic of mature, forest-grown red pine. In the 10-foot spacing, however, there was a tendency for a reversal of this pattern. The average tree specific gravity of the 2-foot spaced trees was 0.328, while that of the 10-foot spaced trees was 0.318. This is a significant difference at the 95% level. The greatest volume of wood, consistent with good tree form, was found to be in the 4-foot spacing which had been thinned to an 8-foot spacing when about 15 years of age.

The pulping qualities of the wood from a 50-year old red pine plantation was also studied. The pulp yield from the butt portion of the trees was significantly greater than from the top portion when based on equal volumes of material. Pulp of higher purity was obtained when using the entire tree than when using only the butt portion. Testing of handsheets showed that burst factor, breaking length, and pulp density values tend to increase with increasing distance above the ground. Microscopical examination of handsheets indicated that areas of probable fiber-to-fiber bonding, observed with polarized vertical illumination, are larger and more frequent in pulp taken from the upper part of the tree as compared to the lower part.

Seasoning characteristics of red pine as well as other aspects of this project will be continued under MS-5009.

#### MISSISSIPPI STATE UNIVERSITY, 3621

##### Shrinkages of loblolly pine.

J. YAO

Shrinkage of loblolly pine wood was found to be significantly influenced by the cardinal orientation of the specimens in the tree. Compression wood was ruled out as being the cause of this effect, since data



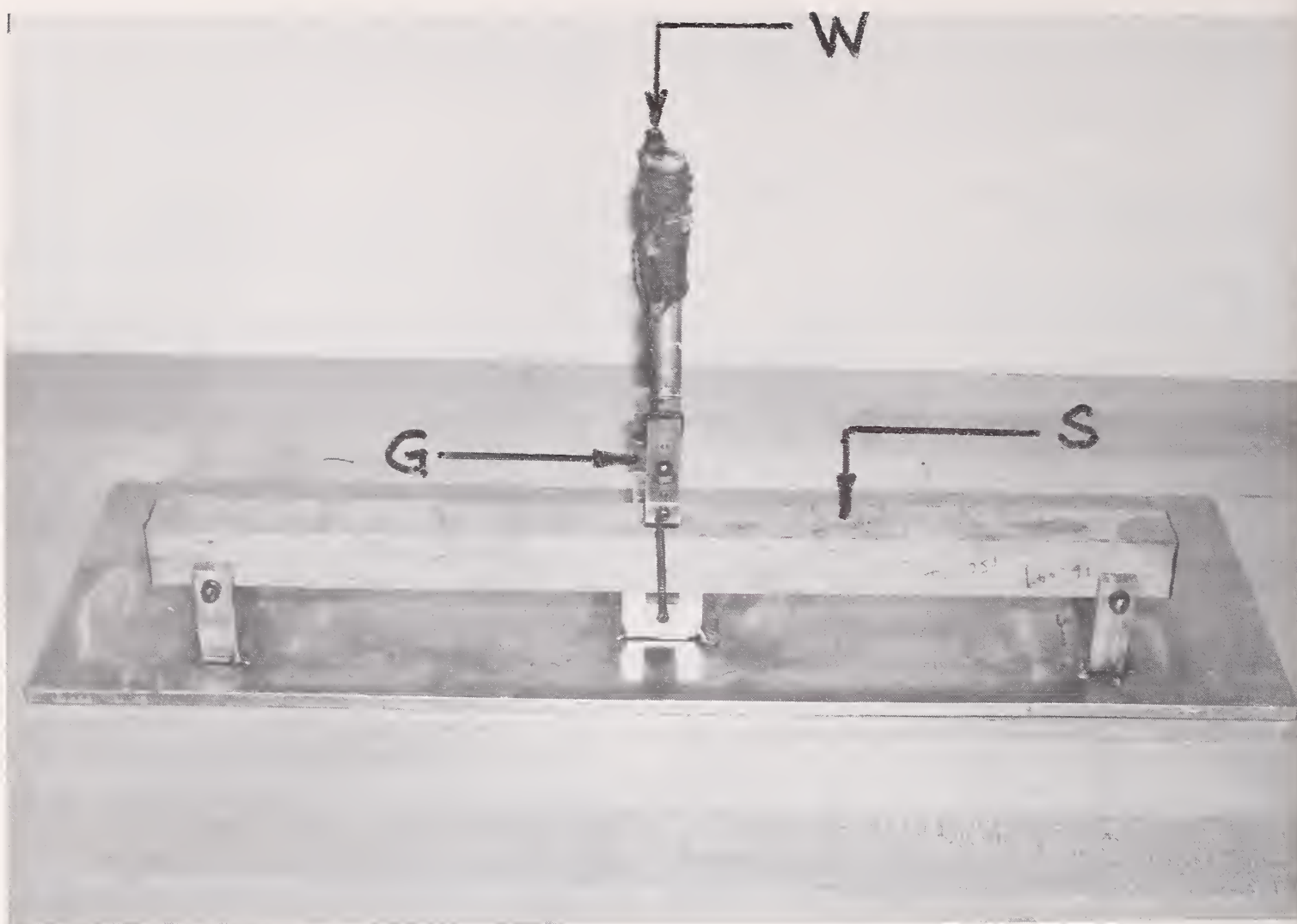


Figure 37. Strain instrument designed to operate inside pressure cylinder. Changes in vertical dimension of wood specimen (S) are sensed by movement of gage arm (G). Signal is transmitted through cylinder wall by connecting lead-wire from instrument (W) to a fitting in cylinder wall similar to a spark plug in an internal combustion engine. Signal is amplified and recorded on strip chart outside cylinder. Wood specimen can be oriented in strain instrument so that dimensional changes in plane either tangent to or perpendicular to growth rings are plotted as a function of time.

analysis revealed that cardinal direction had no influence on specific gravity. Lignin content of wood, however, varied with cardinal direction and was highest on the south side of the pith where the highest shrinkage was recorded. It is suggested that the effect of cardinal direction on shrinkage found in this study is related to lignin content.

The fiber saturation point was also found to have a small but significant effect on volumetric shrinkage. The fiber saturation point, in turn, varied with sampling height. These relationships indicate differences in chemical composition, or perhaps degrees of crystallinity, of the cell wall with height in the tree.

MISSISSIPPI STATE UNIVERSITY, 3624  
Efficiency in lumber manufacture.

W. S. THOMPSON and W. R. FOX

A medium sized (50,000 board feet per day) southern pine sawmill producing standard sizes and grades of boards and dimension lumber was studied. The primary log break-down equipment of the mill was a circular headsaw and a sash-gang resaw. The study was designed to provide descriptive and measurement data sufficient to define and quantify the individual operations and the sequences of operations that take place in the milling of lumber. The collection and analysis of data included two general areas: manufacturing operations and products evaluation. Manufacturing operations were defined primarily by measurements of time and sequences. Products evaluation included measurement of the value of lumber products and chips after manufacture, drying, machining, and final grading. These measurements were used to develop prediction equations based on physical characteristics of logs and prevalent production sequences.

Data reflected only the manufacturing capabilities and operational sequences practiced at the study mill. Therefore, a theoretical analysis based on average manufacturing capabilities and optimum operational sequences was developed to estimate the potential of the study mill, or any mill with similar equipment. Results indicated that the simplest sawing pattern (slabbing to the largest possible cant at the headsaw) produced the largest volume and value of products. Optimum size logs for processing in mills utilizing a headsaw and gang resaw are those in the 10 to 14 inch class. Larger logs, can, of course, be processed more rapidly; but reduced overrun increases the raw material cost for larger logs, at a rate greater than the operational efficiency obtained by higher production rates (Figure 38).

#### NORTH CAROLINA STATE UNIVERSITY, 4002

##### Wood property variation in tupelo gum.

R. L. McELWEE

Wood property information derived for tupelo, sycamore and other hardwoods by this and related

projects is being used by the southern paper industries in their daily acquisition of raw materials for paper production. For instance, work recently completed and now in manuscript form contrasts wood property variation within and between three hardwood species and the influence of this variation on pulp and paper yields and quality. The study answers questions being asked by those responsible for paper production and quality standards.

Newly initiated work will give insight into the inheritance of wood properties important to pulp yield and quality, not well understood in hardwoods; the effects of fertilizers on wood properties, an area of great importance with the current trend to intensive site preparation and commercial applications of fertilizers to forest stands; and dry weight yields of hardwoods growing under the varied environments in which hardwood stands naturally occur. An additional study, now well underway, seeks to identify genetic material capable of growing commercial stands on sites drier than normal. Such

Cost and profit data for sawmilling various sizes and grades of southern pine logs. Tabular values are based on 1000 feet mill tally.

Log Grade	Log Diameter	Cant Thickness	No. of Logs required to produce 1000 ft. mill tally	Sawing Time	Value of Green Lumber	Variable Cost \$9/MMT	Fixed Cost \$550/day	Log Cost per MMT	Profit per MMT	Profit per Hour
	(in.)	(in.)		(min.)	\$	\$	\$	\$	\$	\$
3	6	4	51.03	11.12	54.95	9.00	25.00	57.15	-36.20	-99.55
3	7	4	37.60	8.22	75.52	9.00	18.62	42.11	5.79	21.38
3	8	6	25.21	5.53	61.32	9.00	13.03	28.24	11.05	58.29
3	8	4	28.54	8.02	83.08	9.00	14.30	31.96	27.82	133.70
3	9	6	20.18	5.80	70.22	9.00	10.65	35.31	15.25	98.41
3	10	6	16.42	4.82	73.87	9.00	8.87	41.38	14.62	113.25
2	10	8	15.26	3.37	70.97	9.00	8.62	38.47	14.89	118.68
2	10	6	16.42	4.82	78.52	9.00	8.87	41.38	19.27	149.26
2	11	8	12.77	2.82	74.61	9.00	7.46	43.81	14.34	132.28
2	12	8	10.81	3.31	75.70	9.00	6.53	48.42	11.75	123.70
2	13	10	8.86	2.77	75.95	9.00	7.31	50.26	9.02	84.83
2	14	10	7.70	2.45	75.47	9.00	6.50	53.87	6.09	64.42
2	15	12	6.53	1.46	77.01	9.00	6.05	55.31	6.65	75.15
2	16	12	5.78	1.30	76.17	9.00	5.49	58.22	3.45	43.24
1	17	12	5.14	2.26	77.26	9.00	5.01	60.79	2.45	33.65
1	18	12	4.60	2.08	75.40	9.00	4.60	63.08	-1.28	-19.12

Figure 38.



material is desirable to extend the limited acreage of sites on which hardwoods can produce economic yields.

#### OREGON STATE UNIVERSITY, F-825

Effect of environment and genetic factors on pulping of Oregon woods.

W. J. BUBLITZ and M. D. McKIMMY

The present study was designed to determine the pulping characteristics of permeable and refractory heartwood of Douglas fir. Heartwood samples of both kinds were selected for extremes of water permeability and pulped under constant conditions by the Kraft process.

The refractory pulp produced lower screened yields, contained more lignin, and refined faster to a given freeness level than the permeable pulp. Refractory pulp produced paper with higher density, tensile and zero-span tensile strengths (Figure 39), stretch, and fold endurance while paper made from permeable pulp had higher tear strength and brightness. No difference existed between bursting strength of the two kinds of paper.

Pulp made from refractory heartwood would cost more because of lower screened yields. Cost differential would be greatest for bleached pulp because



Figure 39. Paper made from pulp produced from refractory heartwood had higher tensile strength than permeable pulp.

higher lignin content would mean additional bleaching costs. However, strength advantages of refractory pulp may offset this disadvantage particularly in unbleached grades where higher tensile, stretch and fold strength are more desirable.

#### PENNSYLVANIA STATE UNIVERSITY, 1625

Systems analysis for forest products industries.

P. C. KERSAVAGE

A continuous recording system for monitoring sawmill production was developed as part of this project. A systems analysis of a hardwood sawmill was conducted using this new work measurement approach. Lumber production from over 400 logs was continuously monitored using a system of electronic sensors and recording instruments (Figure 40, 41). The monitoring system was designed to overcome the difficulties of making detailed time studies of a band headrig sawmill using the conventional stop-watch approach. A continuous and permanent record was obtained of the operating characteristics of each of

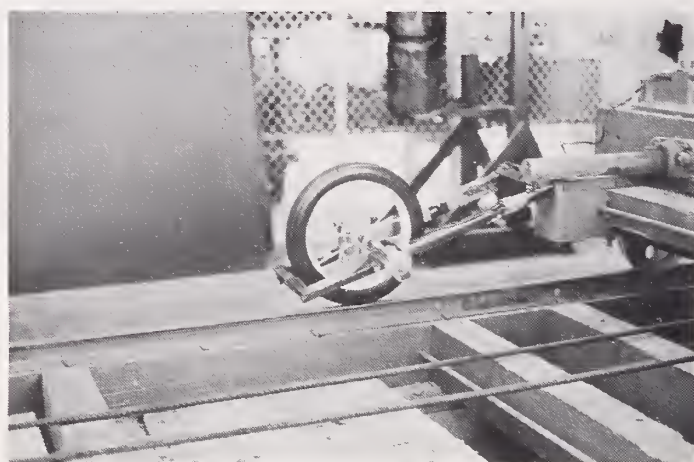


Figure 40. Photoelectric cell monitoring edger production.



Figure 41. Electro-mechanical sensor used for monitoring heading sawing elements.



the principal machines. Such a detailed time study offers several distinct advantages—greater refinement, more precision, and more detailed information. Combined with yield data, it can be used as the basis of a wide range of operational and economic analyses. Study of the monitoring records for cherry lumber indicated inefficiencies in the sawing method. Use of a new sawing method resulted in a 60 percent increase in production, with only a slightly lower grade recovery. A cost analysis indicated use of the new sawing method could increase gross profit by as much as \$230 per day. If these results prove valid for other mills and species, operating efficiency of mills employing the new sawing method could improve significantly.

#### UNIVERSITY OF TENNESSEE, 9

##### Hardwood characteristics.

H. A. CORE

Fiber length measurements have been made of early and latewood zones of bolewood and branchwood of selected yellowpoplar trees. The measurements indicate that the pattern of variation is similar to that reported in the literature. Instances were noted where lengths in springwood were greater than in summerwood of same ring. Fiber lengths in branches are shorter than in bolewood and attain maximum lengths earlier. Fiber lengths in a given growth increment decreased progressively from base of branch to tip. Fiber lengths of given age at measured distances along branch show an inconsistent pattern which merits closer study (Figure 42).

#### WASHINGTON STATE UNIVERSITY, 1775

##### Moisture relationships of wood at high temperature.

M. D. STRICKLER

The moisture relationships of the structural components of grand fir (*Abies grandis* Lind.) were determined isothermally at 130° C. by a water injection technique. These components were lignin, cellulose, holocellulose and hemicellulose and are listed in the order of increasing water adsorptivity. All of these components were more hygroscopic than the whole wood from which they were recovered. The chemical degradation required to separate the wood into its components served to expose adsorption bonding sites that were inaccessible to water in the whole wood.

Hemicellulose, the most hygroscopic structural component of wood, developed an apparent fiber saturation

point in excess of 200 percent moisture content. In its isolated form, the hemicellulose partially dissolved in water at the elevated temperature of the experiment. Fiber saturation points for cellulose, lignin, and whole wood were approximately 50, 40 and 38 percent moisture content respectively at 130° C.

It was observed previously that the hygroscopicity of whole wood increased at high relative vapor pressures as temperature increased above 100° C. This phenomenon was described as inordinate swelling of wood structure. The sorption isotherm for cellulose at 100° showed that cellulose was less adsorptive at 130° than at 100° C. at both low and high relative vapor pressures. It was concluded therefore that the cellulose could not have caused the inordinate swelling of wood, and that hemicellulose was the most likely cause of the phenomenon.

#### WEST VIRGINIA UNIVERSITY, 2

##### Growth rate and specific gravity of hardwoods.

J. R. HAMILTON

The wood of yellow-poplar trees from a field fertilizer experiment at Parsons, West Virginia, was examined during 1969. Fifteen pole-sized trees, to which an application of complete fertilizer had been applied in the fall of 1966, were sampled by extracting two 11 mm. increment cores at breast height. Interest centered on the increment formed prior to fertilization and the two increments formed subsequent to fertilization. Width, specific gravity, and major dimensions of fiber tracheids of the three increments were determined. All characteristics observed were affected by the fertilizer treatment. In the year immediately following fertilization, 1967, increment width was 130 percent and specific gravity was 93 percent of the previous year. The dimensions of fiber tracheids were also affected. Wall thickness was reduced 15 percent, lumen diameter was increased 11 percent, and length was reduced 6 percent. In the second year following fertilization, 1968, the same relationship existed in all these characters but the effects were diminished. These limited data suggest that the feasibility of fertilizer applications in yellow-poplar should be judged not only on the basis of increased wood production but on the quality of wood produced.

The experiment will be repeated using increment cores extracted from a point in close proximity to the



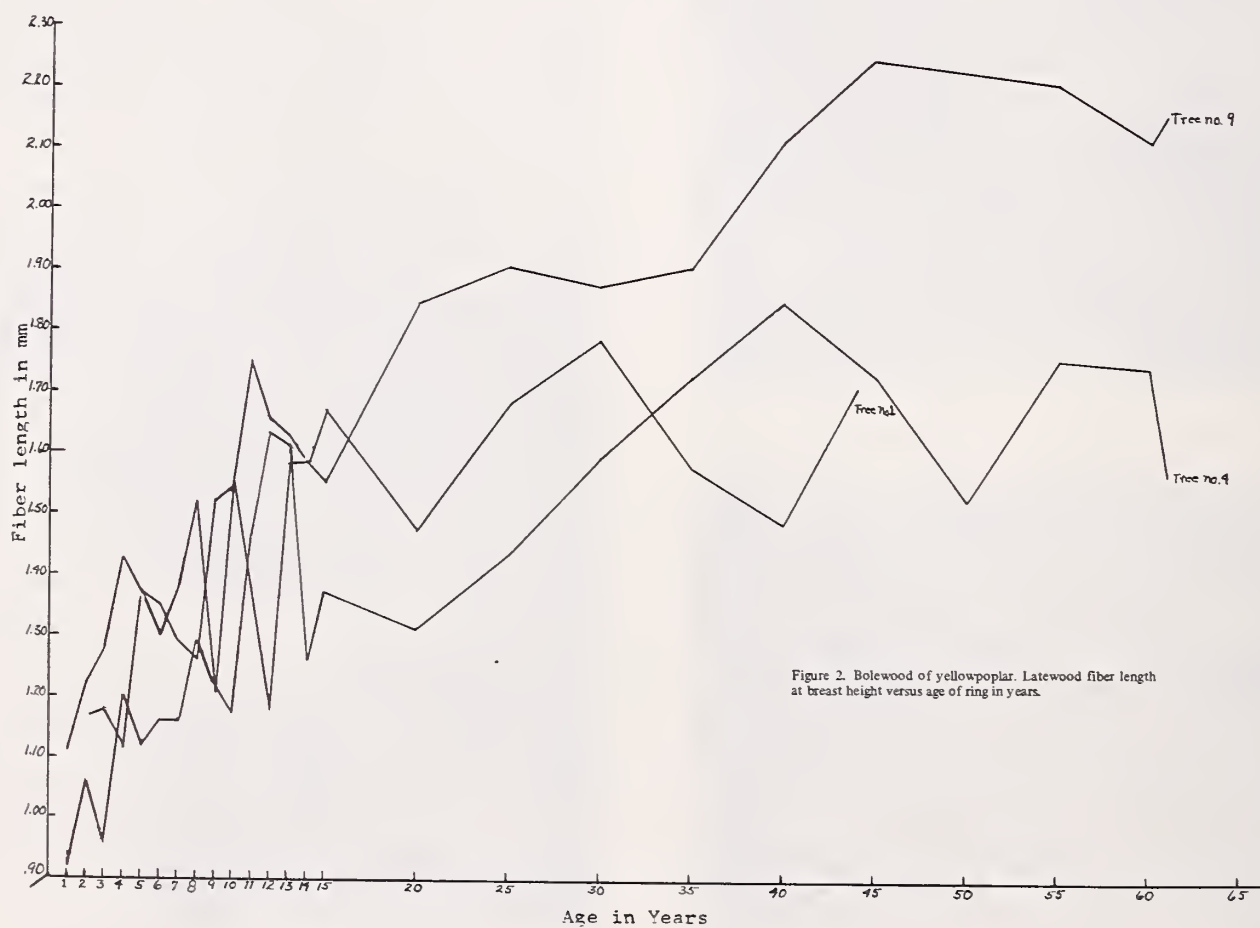
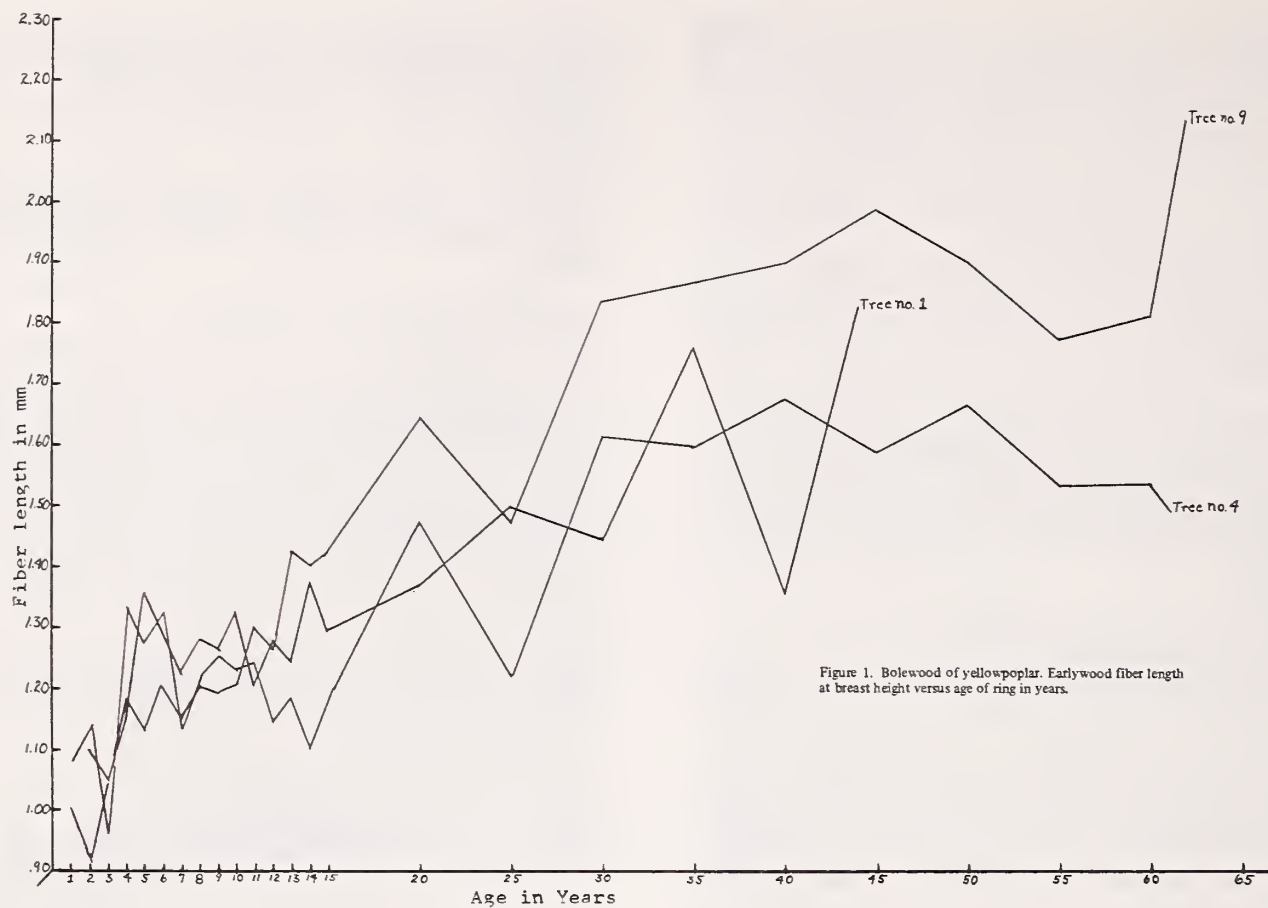


Figure 42.

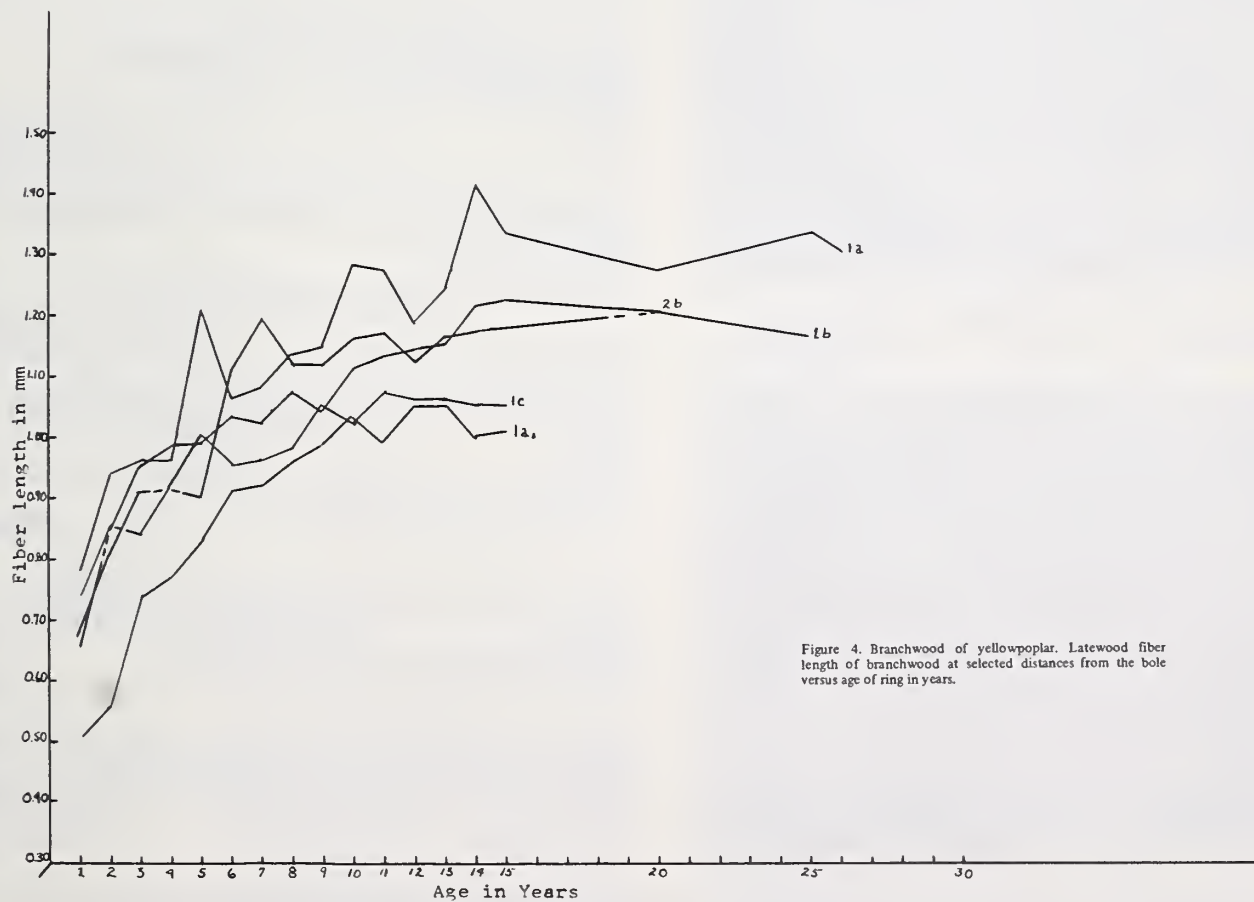
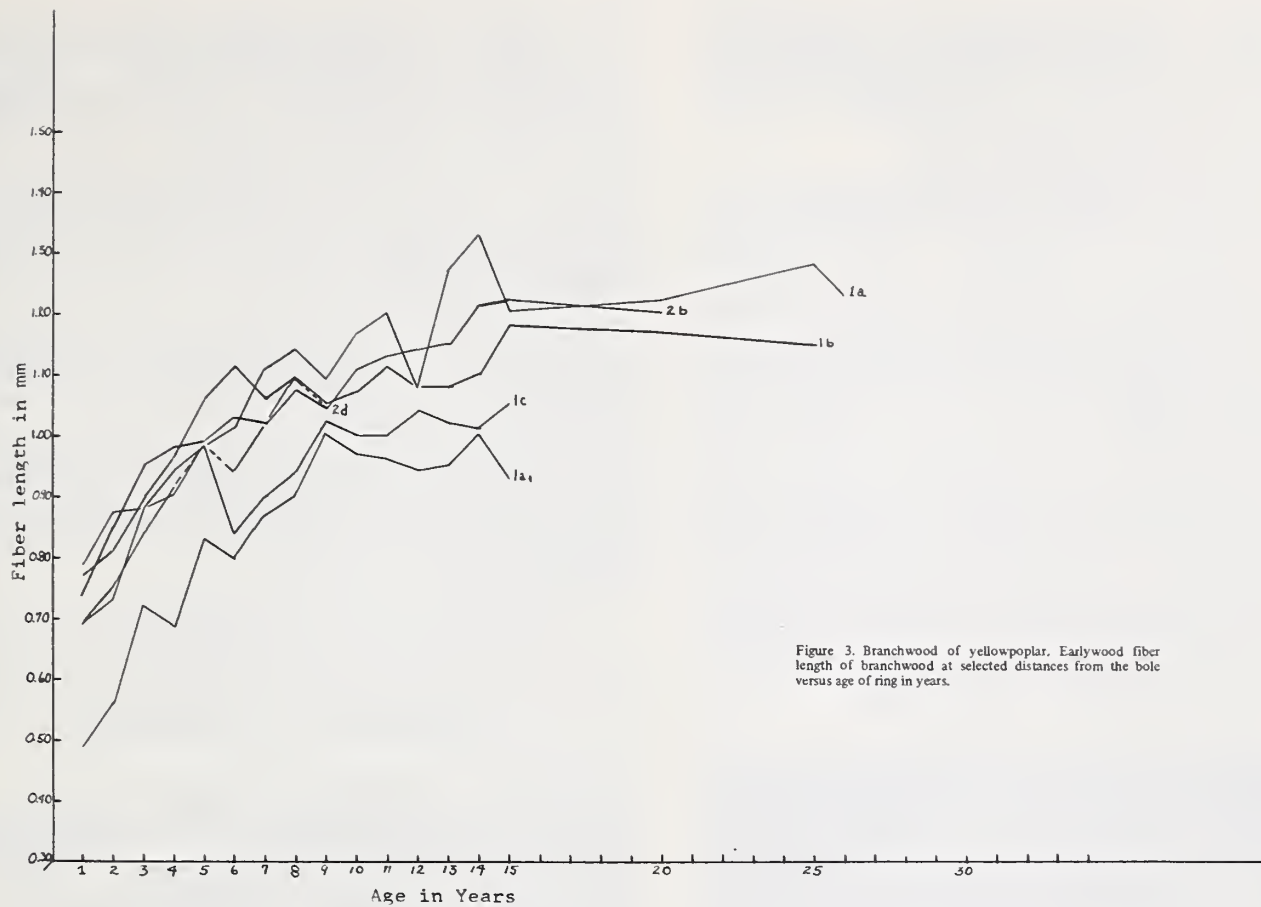


Figure 42.



original sample locations. The purpose of repeating the experiment will be to confirm the original data and obtain information for one additional increment.

#### **UNIVERSITY OF WISCONSIN, 1518**

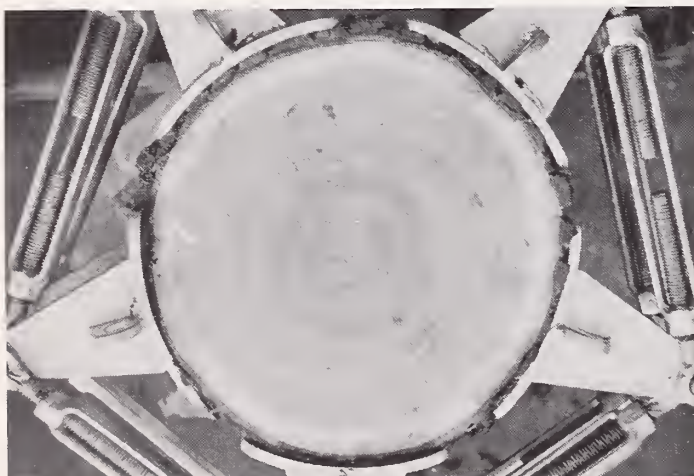
**Avoiding checks in wood and wood products.**

**H. J. KUBLER**

Wood in trees during its formation develops tension stress in grain direction and compression stress in direction of the growth rings. The stress in each new growth ring modifies the stress in the older wood. Across the grain, near the pith, wood comes under tension stress. When the tree is felled and cut into log sections, release of the longitudinal growth stresses near the cuts causes additional tangential tension and heart checks. During steaming or boiling, the heart checks increase as a result of tangential "hygrothermal" expansion of the younger wood.



Oak log section with typical heart check after boiling.



Oak log section adjacent to the one of fig. 1; the circumferential clamp prevented checking.

Figure 43.

We measured the growth stresses at the surface of oak log sections and designed strain gages for evaluating the stresses inside the logs. A circumferential clamp was built for log ends. In boiling tests with oak logs the clamp prevented formation of heart checks (Figure 43). To find the prerequisites of hygrothermal dimension changes, wood was heated under different conditions. An electrical displacement transducer indicated the dimension changes. These experiments failed to provide the expected clarification, because the oak specimens had slightly collapsed during drying at 36°F and the collapse was partly removed during heating. However, the experiments led to another discovery: temperatures above 130°F removed collapse not only in wet wood but also at moisture contents as low as 10 percent.

#### **ADDITIONAL PROJECTS**

**ALABAMA - AUBURN UNIVERSITY, 905**

**Anatomy of figured wood.**

**H. O. BEALS**

**ALABAMA - AUBURN UNIVERSITY, 910**

**Strength of plastic-overlaid pine plywood and particleboard.**

**E. J. BIBLIS**

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**Wood quality and growth of Southwestern ponderosa pine.**

**G. VOORHIES**

**UNIVERSITY OF CALIFORNIA - BERKELEY, 2181**

**A study of the wood machining process.**

**J. D. CUMMING**

**UNIVERSITY OF CALIFORNIA - BERKELEY, 2495**

**Chemistry and utilization of bark.**

**A. B. ANDERSON**

**UNIVERSITY OF CALIFORNIA - BERKELEY, 2553**

**Heating methods in the drying of wood.**

**H. RESCH**

**COLORADO STATE UNIVERSITY, 320**

**Multi-component binder systems for particleboard manufacture.**

**H. E. TROXELL, F. F. WANGAARD**

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**Properties of lodgepole pine infected by dwarf mistletoe.**

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Fiber length in southwestern young-growth ponderosa pine. *Forest Products Journal* 19(5):52-55. 1969.

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Shrinkage properties of second-growth Southern yellow pine. *Wood Science and Technology.* 3(1):25-39. 1969.

**ZIEGLER, G. A.**

The effects of thermal energy and tensile loads parallel to the grain on theological properties of pseudotsuga menziesii F, M.S. Thesis, The Pennsylvania State University. 1969.

## IMPROVEMENT OF GRADES AND STANDARDS OF FOREST PRODUCTS

### Research Problem Area 512

Grades and standards describe the characteristics of a product so that producers and processors, and buyers and sellers can gage product utility. Tree grades provide a means of more effectively valuing growing stock, thus assisting the producer to set specific goals for silvicultural practice and to obtain true value for stumpage. Log grades reduce the uncertainty in product transactions and permit segregation of logs for their highest use, to the benefit of both buyer and seller. Standards for processed forest products likewise assist buyers in obtaining product characteristics they desire and sellers in obtaining appropriate compensation for what they sell. Because wood is by nature a very heterogenous material, the efficiency of the whole structure of wood markets depends to a large degree on the existence of accurate and understandable grades and standards.

**WASHINGTON STATE UNIVERSITY, 1929**

Factors affecting the vibrational parameters of structural lumber. **R. F. PELLERIN**

The objective of this project was to determine the influence of the location of defects on vibrational parameters of lumber. Such information is pertinent to the use of vibrational techniques for characterizing nondestructively the mechanical properties of individual pieces of lumber.

The test specimens consisted of 185 inland Douglas fir 2 x 6's which had been selected to contain one major defect per piece. Localized grain deviations, center knots and edge knots constitute the types of defects. The specimens were conditioned to 6 percent moisture content and were analyzed with transverse vibrations for their vibrational parameters. Within each piece, the major defect was then effectively moved stepwise toward one end by removing two-foot increments. After removal of each increment, the transverse vibration analysis was repeated.

Each specimen was trimmed ultimately to a length of eight feet. Thus, prior to the final vibration analysis, a defect which occurred approximately mid-span of a 16-foot piece would be removed completely in trimming to eight feet. Data were gathered in such a manner that the influence of the defect location along the length of a specimen could be observed.

Natural defects in the specimens which were not considered to be major in magnitude influenced the vibrational parameters significantly, and the results were, therefore, inconclusive. In general, however, the influence of defect location on vibrational parameters is most significant at mid-span and it diminishes linearly to little or no influence when occurring near the ends.

## ADDITIONAL PROJECTS

**UNIVERSITY OF CALIFORNIA - BERKELEY, 2357**

The marketability of veneer and plywood from young-growth California pine and redwood.

**F. E. DICKINSON**

**UNIVERSITY OF KENTUCKY, 601**

Important hardwood log breakdown.

**D. B. RICHARDS**

**UNIVERSITY OF WASHINGTON, 23**

Models for wood quality.

**J. S. BETHEL**



## **PUBLICATIONS**

**CUMMING, J. D., C. FISCHER and F. E. DICKINSON.**

Rotary veneer cutting characteristics of young-growth redwood. *Forest Products Journal*. Vol. 19(11):26-30. 1969.

**DICKINSON, F. E.**

Products and opportunities for living through new products. *Proceedings of the 59th Western Forestry Conference*. San Francisco, California. 1968.

### **HOUSING FOR RURAL AND URBAN FAMILIES**

#### **Research Problem Area 801**

Housing, as individual units and collectively, has a significant impact on the quality of rural living. Tremendous opportunities exist for research to reveal effective, economical procedures and materials for renovating and modernizing existing houses as well as in design and development of new housing.

**IOWA STATE UNIVERSITY, 1744**

Assessing consumer preferences for housing.

**D. R. PRESTEMON**

Data from the survey was carefully analyzed and a technical paper reporting major results was written. The methodology employed and the information generated are being used in the design of a substantive study on housing for lower income people.

This project will terminate June, 1970. Submission of a new project for state funding is planned.

### **ADDITIONAL PROJECTS**

**INDIANA - PURDUE UNIVERSITY, 1353**

Analytical design of wood trussed rafters.

**S. K. SUDDARTH**

**UNIVERSITY OF KENTUCKY, 1015**

Use of Appalachian lumber.

**J. N. WALKER**

## **PUBLICATIONS**

None

### **ALLEVIATE SOIL, WATER, AND AIR POLLUTION**

#### **Research Problem Area 901**

Soil, water, and air are being polluted with a variety of substances, both inorganic and organic. Some of the more apparent contaminants are organic pesticides, radionuclides in fertilizers, growth regulating chemicals, animal and crop wastes, mulching materials, pathogenic microorganisms, heavy metals, salts used on roads for de-icing, lead from fuel combustion, allergins, and radioactive fallout. Agricultural research must be primarily concerned with alleviating pollution initiated by agricultural and forestry practices.

**NORTH CAROLINA STATE UNIVERSITY, 4017**

Control and treatment of pulp and paper mill effluent.  
**C. N. ROGERS**

The survey included 47 pulp and paper mills, producing about 49,800 tons of pulp and 45,100 tons of paper per day, which is approximately 65% of the pulp production of the South. The amount of waste water discharged from an integrated Kraft pulp and paper mill producing unbleached products varies from 9,300-29,400 gal per ton of product. The untreated waste waters contain from 19.5 to 60 lbs of BOD<sub>5</sub>, 10-99 lbs of suspended solids, and 84-530 lbs of dissolved solids per ton of product.

37 of the surveyed mills had primary treatment and 26 of these had secondary treatment of their waste water. Total amount of waste water in all the mills amounted to about 1,200 million gal/day (MGD). Primary treatment was performed in mechanical clarifiers (Figure 44) in 26 mills (671 MGD) and in earth basins in 11 mills (274 MGD) and removal of suspended solids varied from 55 to 98%. Secondary treatment in 13 mills (247 MGD) was performed in storage lagoons, 9 mills (276 MGD) used aerated lagoons often followed by impoundment, and 4 mills



Figure 44. Primary clarifier retention pond and mechanical areators.



Figure 45. Typical installation using the activated sludge process.

(110 MGD) used activated sludge. The efficiency of BOD removal varies from 10-95% in the storage lagoons, from 50-90% in the aerated lagoons and from 70-90% in the activated sludge treatment (Figure 45). Only one mill carried out color removal treatment. Principal problems are dewatering and disposal of the sludge from primary and secondary treatment, and meeting governmental standards for secondary treatment in lagoons. A report will be published next year.

## ADDITIONAL PROJECTS

NORTH CAROLINA STATE UNIVERSITY, 4025  
Pulp industry pollution abatement through process  
modification. P. J. KLEPPE

## PUBLICATIONS

None



## Chapter 9

# FORESTS AND FORESTRY FROM THE NATIONAL POINT OF VIEW

The United States is currently experiencing sharply increasing demands for all types of land, including forested land, at prices which are frequently beyond the value of the land for forestry purposes. As a result many large companies in basically forest industries must plan to derive income from not only forest operations but from many uses of their lands such as hunting and other recreational enterprises. Apparently this trend will continue to intensify as the population and leisure hours of the nation increase.

Other needs of the nation, especially for water, will have a greater influence on land use in the future. Leaders in these matters must have the benefit of historical perspective, present situation, and an appreciation of the direction forestry is taking to meet very serious national concerns. Recently, the impact of recreation has been most serious and has, thus, resulted in research in recreational research around the nation. The possibilities in multiple-use of forest land have also produced a sizable effort to study these potentialities. There is still an unfilled need for research data obtained from studies of recreational problems and possibilities.

### ALTERNATIVE USES OF LAND

#### Research Problem Area 104

Alternative uses of land need to be evaluated to determine which ones will provide the greatest short-and long-range social and economic benefits. Population growth, advances in agricultural technology, changing consumer demands, urban and suburban growth, needs of people at home and abroad, recreational needs, and other factors result in changing demands upon our nation's fixed supply of land. Soil conservation, and water, watersheds, recreation and community development programs and policies should be based upon the relative advantages of alternative land uses.

### ADDITIONAL PROJECTS

UNIVERSITY OF DELAWARE, 715-E  
Wildland ecology and urban impact.

R. JONES

### COMMUNICATION AND EDUCATION PROCESSES

#### Research Problem Area 805

Effective communication is vital to the educational process, the dissemination of knowledge, development of sound public policy, successful conduct of public programs, and development of understanding among groups in our society.

Research on communication will assist in obtaining agreement on the most important problem; gaining public support for research on the problems; and reducing the time lag between discovery and development and the adoption of improved practices and products.

Research on education processes is needed to determine effective ways to achieve educational goals.

## ADDITIONAL PROJECTS

### NEW YORK - CORNELL UNIVERSITY, 908

Susceptibility of absentee forest landowners to forestry education. A. DICKSON

## OUTDOOR RECREATION

### Research Problem Area 902

Outdoor recreational research provides information to guide the use and management of forest and rural lands for recreation, and to help coordinate this use with other land resource uses. The research involves problems in management of the resource and socio-economic relationships of users to the resource. Recreation demands continue to increase, and are becoming more varied and more complex, at a time when pressure on all land resources is accelerating.

### NORTHERN ARIZONA UNIVERSITY, 6

Management of the forest recreation resource in Arizona. L. S. LOVE and A. J. SCHULTZ

During the summers of 1968 and 1969, family-unit use at two water-based and two non water-based forest campgrounds was inventoried by three methods, observation, questionnaire and physical description, to determine (1) recreation user characteristics, (2) family unit design preferences and (3) validity of methods used. At water-based campgrounds parties using individual units were families averaging 3 to 4 persons while, at non water-based campgrounds, parties consisted of organized groups or family gatherings averaging 5 to 6 persons per unit. Parties using family units at water-based campgrounds were usually on vacation averaging 5 to 6 days duration whereas parties using non water-based campgrounds usually stayed 2 to 3 days over a weekend. A higher proportion of picnicking parties visited non water-based campgrounds than water-based campgrounds. The latter were usually used by camping parties. During both years, age and equipment distributions varied at the campgrounds. Recreation users of the four campgrounds preferred family units that were close to vehicle parking and contained a large parking area. The observation method provided dependable data particularly when used in conjunction with the questionnaire and physical description methods. The questionnaire proved useful in eliciting unobservable

user characteristics, i.e., length of stay, camping experience, but not in providing discreet values of family unit design preferences. Information of the above nature will aid in the development of design standards that will provide a more uniform use of developed campgrounds.

### CALIFORNIA - HUMBOLDT STATE COLLEGE, 13

The optimum mix of undeveloped and developed land within a hyleopolis. E. W. PIERSON

Approximately 3000 questionnaires were mailed out and 760 returned. Information was placed on IBM cards, a program written and basic data printed out for further analysis. 90% of the permanent site study plots have been established. A final analysis of the data on the IBM cards is underway and a final report is being prepared.

### COLORADO STATE UNIVERSITY, 313

Colorado forest areas and mountain recreation.

A. T. WILCOX

Inventory reports completed but not printed during the previous period were further refined by field examination of selected inventory areas to verify field procedures used in the initial study.

Inventory data were analyzed to determine more efficient methods for its utilization in the development of regional recreation plans. This analysis and final inventory reports, are in the process of completion.

### UNIVERSITY OF CONNECTICUT, 390

The role of the forest in open space planning in Eastern Connecticut.

M. J. GRATZER and R. D. McDOWELL

- 1) A mathematical landscape preference model has been tested with two separate groups of respondents (Connecticut and Montana). The results indicated that the model is an applicable one, and with some modification a reliable tool for landscape management decision making.
- 2) Preferences for individual tree species also have been tested with the above groups. Results indicated that the respondent's regional (or geographical) background strongly influences value judgments.



- 3) Nine respondents' eye movement and scanning patterns over a set of landscape photographs were successfully recorded on 16 mm film (Figure 46).

**MICHIGAN TECHNOLOGICAL UNIVERSITY,  
3016**

**Recreational opportunities on industrial forests in the  
Keweenaw Bay area, Michigan. C. R. CROWTHER**

This study identifies recreational policies and programs of 18 companies which own forest properties

in the Keweenaw Bay area of the Upper Peninsula of Michigan. Five industry types are classified, and recreation policy and program differences among these types are identified. Factors accounting for differences among company types are postulated. During the past year, a survey of 31 similar companies throughout the Lake States region was conducted. Results of this survey are being compared with the findings from Michigan's Upper Peninsula. Completion is expected during 1970.



Figure 46. The visual perception of various landscapes by the respondent being recorded on an Eye Movement Recording System. University of Connecticut #390.

## ADDITIONAL PROJECTS

### UNIVERSITY OF ARIZONA, 620

Forest recreation demand analysis. D. A. KING

### UNIVERSITY OF IDAHO, 4

Methods for estimating recreational visits and use on unattended recreation sites. H. R. ALDEN

### SOUTHERN ILLINOIS UNIVERSITY, 66-R-3

Private horseback riding enterprises. D. R. McCURDY

### SOUTHERN ILLINOIS UNIV., 16

An outdoor recreation corridor system. H. GIESBRECHT

### SOUTHERN ILLINOIS UNIVERSITY, 67-R-23

Techniques for measuring recreation use of land. D. R. McCURDY

### SOUTHERN ILLINOIS UNIV., 66-R-26

A master plan for Devils Kitchen Lake. D. R. McCURDY

### IOWA STATE UNIVERSITY, 1580

Forest-recreation investment opportunities. H. H. WEBSTER and F. S. HOPKINS

### LOUISIANA STATE UNIVERSITY, 1232

An evaluation of the effect of State forests and parks on public recreational use of private forests. R. W. McDERMID

### UNIVERSITY OF MAINE, 5010

Recreation and forest land use planning. J. C. WHITTAKER, A. D. NUTTING and T. J. CORCORAN

### UNIVERSITY OF MARYLAND, T-16

Forest recreation - The values placed on trees for recreation environment. F. H. FORSYTH

### UNIVERSITY OF MICHIGAN, 6

Factors influencing attendance at forest recreation sites. G. R. GREGORY

### UNIVERSITY OF MICHIGAN, 16

Attitudes of professional foresters toward uses of forest lands for recreation purposes. B. L. DRIVER

### MICHIGAN STATE UNIVERSITY, 1029

The recreation capacity of a small lake and implications for planning and development. M. CHUBB

### MICHIGAN STATE UNIVERSITY, 1038

Recreational trail use and user characteristics in Michigan. M. CHUBB

### MICHIGAN TECHNOLOGICAL UNIVERSITY, 3023

Sylvania National Recreation Area and its local economic influence. W. R. WYND and C. R. CROWTHER

### UNIVERSITY OF MINNESOTA, 19-43

Recreation land management and user satisfaction at several Minnesota park and forest areas. L. C. MERRIAM, JR.

### UNIVERSITY OF MINNESOTA, 19-77

Ecological implications of the management of Itasca State Park to meet recreational objectives. H. L. HANSEN

### UNIVERSITY OF MONTANA, 804

Recreation use of forest lands in Montana. S. S. FRISSELL

### UNIVERSITY OF NEVADA, 672

Recreational uses and factors influencing their quality and quantity in isolated forest and rangelands. P. T. TUELLER and J. B. WOODY

### UNIVERSITY OF NEVADA, 673

Recreational potential of the Truckee River Basin. C. S. SALADINE II

### NEW YORK - STATE UNIVERSITY COLLEGE OF FORESTRY AT SYRACUSE UNIVERSITY, 902-0-1

Aesthetic reactions to forest scenes. W. D. WENGER, JR.

### PENNSYLVANIA STATE UNIVERSITY, 1494

Wildland recreational management. J. L. GEORGE, J. S. LINDZEY, R. A. BARTOO and W. W. WARD

### PENNSYLVANIA STATE UNIVERSITY, 1836

Wildland recreational management. J. L. GEORGE and G. W. WOOD



PENNSYLVANIA STATE UNIVERSITY, 1842  
Effects of land use changes on the scenic qualities of  
Pine Creek, Pennsylvania. P. W. FLETCHER

SOUTH DAKOTA STATE UNIVERSITY, 420  
Establishment of tree plantings to enhance recreation  
potential of selected sites. E. COLLINS

UNIVERSITY OF TENNESSEE, 5  
Recreation resources of large private forest owner-  
ships. K. F. SCHELL

TEXAS A & M UNIVERSITY, 1660  
Use of attitude measurement as a method of pre-  
dicting recreation policies of large forest landowners  
in east Texas. R. L. BURY

UTAH STATE UNIVERSITY, 739  
Interagency cooperation for Flaming Gorge National  
Recreation Area. R. A. OGLE

UTAH STATE UNIVERSITY, 778  
The nature of urban recreation on the public forests  
of Utah's Wasatch Front. R. A. OGLE

UNIVERSITY OF VERMONT, 15  
Comparative economic analysis of public recreation  
land in forested areas in Vermont and the Northeast.  
F. O. SARGENT

WASHINGTON STATE UNIVERSITY, 1848  
Guidelines for recreation in multiple use land manage-  
ment. M. MOSHER and C. D. MATTSON

WASHINGTON STATE UNIVERSITY, 1914  
A method for selecting public recreation investments  
which will increase social benefits.  
C. D. MATTSON, W. BUTCHER  
and G. M. SOUTHWARD

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munities in Itasca State Park, Minnesota. Minnesota  
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KURMIS, V. and H. L. HANSEN.  
Occurrence and distribution of pine reproduction in  
Itasca State Park, Minnesota. Minn. Forestry Re-  
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"Eye Pupillary Measurement of Aesthetic Responses  
to Forest Scenes." Journal of Leisure Research 1(2):  
149-161. 1969.

WEST, P. C., S. F. McCOOL and L. C. MERRIAM, JR.  
Types of camping in two Minnesota areas: A study of  
preference intensity. Minnesota Forestry Research  
Note 203. School of Forestry, University of Minne-  
sota. 4 pages. April 15, 1969.

## MULTIPLE USE POTENTIAL OF FOREST LAND AND EVALUATION OF FORESTRY PROGRAMS

### Research Problem Area 903

Most forest areas and related resources can be  
devoted to widely varying uses depending on the  
owner's objective and the allocation of investments  
for resource development. On more than 300 million  
acres of National Forests and other public lands, for  
example, guidelines are needed to determine the best  
combination of uses or systems of managing forest  
land for timber, water, forage, recreation, wildlife, or  
other purposes.

Forestry programs to increase production of timber  
and related forest resources need to be evaluated to  
determine their relative costs and effectiveness. These  
programs cover a wide range of activities including  
protection against fire, insects and disease; reforesta-  
tion; timber stand improvement; and improved  
timber harvesting.

UNIVERSITY OF WASHINGTON, 3  
Recreational uses of forest lands. G. W. SHARPE

The University of Washington has a forested tract of  
land (Marckworth Forest) which has three primary  
uses, namely: public outdoor recreation, timber har-  
vesting and forestry research. The development of a  
management tool in the form of a plan to orient the  
public utilizing the forest for recreational purposes on

the need for respecting the restrictions imposed by the other forest uses and preserving the wildland status quo has reached the first draft stage.

The focal point of this plan is interpretation of natural history, concentrating on forest and marsh ecology. Through interpretation it is hoped that visitor enjoyment and satisfaction with the forest can be increased, while manipulation of their impact, behavioral characteristics and attitudes can be shaped (Figure 47).

To produce this plan an inventory of interpretative resources was taken. To choose the most suitable resources for interpretation, the spatial aspects of these resources were then considered with respect to existing and proposed roads, trails, University experiments, circulation patterns and timber harvest plans. Other important considerations were: (1) orienting the visitor upon arrival in the forest, on parking areas, sanitation and water, (2) facilities producing a "total" ecologic picture and (3) interpretive media.

## ADDITIONAL PROJECTS

**SOUTHERN ILLINOIS, 65-R-13**

Taxation of multiple-use forest land.

**R. I. BEAZLEY**

**SOUTHERN ILLINOIS UNIVERSITY, 67-R-1**

Economic allocation and use of resources for forestry.

**R. I. BEAZLEY**

## A RECREATIONAL RESOURCE



Figure 47. The University of Washington's Marckworth Experimental Forest, and its numerous active beaver colonies provide an outstanding resource for interpreting natural history to recreationists.

**SOUTHERN ILLINOIS UNIVERSITY, 69-R-B**

A study of the trend in forest exchange in southern Illinois.

**R. M. MISCHON**

**INDIANA - PURDUE UNIVERSITY, 1354**

Management of outdoor recreation resources.

**D. M. KNUDSON**

**UNIVERSITY OF MISSOURI, 617**

Assistance programs on private forestry.

**J. M. NICHOLS**

**UNIVERSITY OF MONTANA, 2001**

Evaluating forest resource multiple use.

**W. K. GIBSON**

**UNIVERSITY OF NEW HAMPSHIRE, 6**

Forest land resources in the economy of New Hampshire.

**B. B. FOSTER**

**NEW JERSEY - RUTGERS UNIVERSITY, 256**

Evaluation of the multiple uses of New Jersey's public forest land resources.

**R. F. WEST and R. ROGERS**

**NEW YORK - STATE UNIVERSITY COLLEGE OF FORESTRY AT SYRACUSE UNIVERSITY, 10272-N**

Management decision models as they relate to multiple use forest management.

**R. E. GETTY**

**NORTH CAROLINA STATE UNIVERSITY, 4003**

Foundations of American forest policy.

**J. O. LAMMI**

**UNIVERSITY OF RHODE ISLAND, 125**

Development of Rhode Island forested lands.

**C. GRATTO**

**UNIVERSITY OF VERMONT, 6**

Economics of multiple use of forested land.

**F. O. SARGENT**

## PUBLICATIONS

**GRATTO, C. P.**

Role, potential and appraisal of industrialization in promoting structural improvement and optimal spatial distribution of the population. Iowa State Univ. CAED Symposium, May, 1969.



## **IMPROVEMENT OF RURAL COMMUNITY INSTITUTIONS AND SERVICES**

### **Research Problem Area 908**

This research supplements that on improving income opportunities in rural communities. It will help identify the ways by which rural communities can develop the organizations, agencies, services, and leadership needed to make them attractive places to live, work, and establish businesses.

Some rural communities are greatly in need of research information to help in adjusting to sharp increases or decreases in population. Modern transportation and communication have contributed to the development of trading and social centers serving large geographic areas, and have caused the decline or elimination of a great many small centers. Uncoordinated development and other changes in land use, with no reference to any overall plan, often make it impossible to provide public services economically. These are among the reasons why rural communities encounter severe difficulties in meeting the changing needs of people at a cost they can afford.

#### **LOUISIANA POLYTECHNIC INSTITUTE, 6**

Workmen's compensation and safety in timber harvesting and wood-using mills, Arkansas and Louisiana.

**E. J. CAROTHERS**

During the summer of 1969, 51 managers or owners of primary wood-using mills in Arkansas were interviewed. Work on the resulting questionnaires will begin soon.

No timber harvesting crews nor raw wood dealers have been interviewed as yet.

Louisiana questionnaires need to be brought up-to-date so that comparisons can be made with those from Arkansas. This will be done by mail as much as possible.

### **ADDITIONAL PROJECT**

**UNIVERSITY OF MONTANA, 205**

Montana forest property taxing procedure.

**W. K. GIBSON**

### **PUBLICATION**

**CAROTHERS, J. EDWIN.**

"Workman's compensation researched," American Pulpwood Ass'n, pp. 17-18. July 1969.

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Utah State Univ.	1761	Pine Plantations.	D. M. Moehring .....	69
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Table I. Summary of McIntire-Stennis Forestry Research Project Activity during 1969

Institutions	Chapter I	Chapter II	Chapter III	Chapter IV	Chapter V	Chapter VI	Chapter VII	Chapter VIII	Chapter IX	Total Number of Projects	Scientists	Graduate Scientists	Publications
Alabama, Auburn Univ.	4	1	-	2	1	-	-	2	-	10	8	3	4
Alaska, Univ. of	2	-	-	-	-	-	2	-	-	4	4	1	2
Arizona, Univ. of	2	-	-	2	1	-	-	-	1	6	5	4	6
Arizona, Northern Univ.	-	2	-	-	2	-	-	1	2	7	7	3	3
Arkansas, Univ. of	1	-	-	4	-	-	-	-	-	5	5	9	5
California, Univ. of	1	1	-	3	3	2	2	4	-	16	17	27	13
California, Humboldt St.	2	4	-	-	1	-	-	-	1	3	13	11	5
Colorado State Univ. of	6	-	-	1	2	-	-	3	1	13	17	5	5
Connecticut, Univ. of	2	-	-	-	1	-	-	-	1	4	5	0	13
Conn. Ag. Exp. Sta.	3	-	-	-	-	-	-	-	-	3	2	3	0
Delaware, Univ. of	-	1	-	-	-	-	-	-	1	2	2	4	1
Florida, Univ. of	6	-	-	2	-	-	-	-	-	8	8	0	4
Georgia, Univ. of	4	2	-	1	1	1	-	1	-	10	7	11	7
Hawaii, Univ. of	3	-	-	2	-	-	-	-	-	5	8	0	0
Idaho, Univ. of	3	3	-	2	-	-	1	2	1	12	11	10	4
Illinois, Univ. of	2	-	-	-	-	-	1	1	-	4	3	0	2
Illinois, S.I.U.	3	2	-	-	1	-	-	3	7	16	8	14	1
Indiana, Purdue Univ.	1	1	-	-	1	-	-	2	1	6	6	7	3
Iowa State Univ.	1	-	-	-	-	-	-	2	1	4	8	6	3
Kansas State Univ.	1	2	-	1	-	-	1	-	-	5	3	3	8
Kentucky, Univ. of	2	-	-	-	-	-	-	-	4	6	7	4	4
Louisiana State Univ.	2	3	1	-	-	-	1	2	1	10	10	10	7
Louisiana Tech.	-	4	-	2	-	-	-	1	1	8	11	6	4
Maine, Univ. of	3	1	-	1	-	-	-	3	1	9	16	10	16
Maryland, Univ. of	1	-	-	2	-	-	1	-	1	5	6	5	3
Massachusetts, Univ. of	4	-	-	1	1	-	-	2	-	8	10	12	7
Michigan, Univ. of	4	-	-	3	-	-	-	-	2	8	5	11	5
Michigan State Univ.	3	1	-	1	-	1	-	2	2	10	10	12	8
Michigan Tech.	4	-	1	1	1	-	-	-	2	9	9	2	1
Minnesota, Univ. of	4	2	-	2	1	-	-	3	2	14	18	15	9
Mississippi State Univ.	2	1	-	1	-	-	-	6	-	10	8	5	3
Missouri, Univ. of	5	-	-	-	-	1	-	1	1	8	7	11	7
Montana, Univ. of	4	2	-	1	1	-	1	1	3	13	13	14	5
Nebraska, Univ. of	1	1	-	-	-	-	-	-	-	2	4	3	0
Nevada, Univ. of	2	1	-	-	-	-	-	-	2	5	3	1	0
New Hampshire, Univ. of	-	2	-	1	-	1	-	1	1	6	5	2	2
New Jersey - Rutgers	2	-	-	1	-	-	-	-	1	4	4	5	1
New Mexico State Univ.	2	1	-	1	-	-	2	-	-	6	5	1	2
N.Y., Cornell Univ.	5	1	-	-	1	-	-	-	-	8	9	0	4
N.Y., SUNY, Syracuse	5	1	-	-	1	-	-	2	3	11	17	0	8
North Carolina St. Univ.	8	1	-	1	1	1	1	10	1	24	30	4	18
North Dakota St. Univ.	-	1	-	-	-	-	-	-	-	1	1	0	0
Ohio, OARDC, Wooster	3	1	-	1	-	-	-	-	-	5	6	0	2
Oklahoma State Univ.	6	2	-	1	1	-	-	1	-	11	7	6	7
Oregon State Univ.	8	-	-	2	4	1	-	5	-	20	19	18	6
Pennsylvania State Univ.	2	3	-	3	-	-	-	5	3	16	16	11	13
Puerto Rico, Univ. of	-	-	-	3	-	-	-	-	-	3	2	0	0
Rhode Island, Univ. of	3	-	-	-	-	-	-	-	1	4	6	4	1
S.C., Clemson Univ.	7	2	-	1	-	1	-	-	-	11	10	3	2
South Dakota St. Univ.	1	2	-	-	-	-	-	-	1	4	3	1	1
Tennessee, Univ. of	5	3	-	1	-	1	-	1	1	12	7	7	1
Texas A & M Univ.	2	1	-	2	1	-	1	1	1	9	8	6	1
Utah State Univ.	4	2	-	-	1	-	1	-	2	10	6	4	1
Vermont, Univ. of	4	4	-	-	1	1	-	-	2	12	11	2	5
Virginia Tech.	4	4	-	-	-	-	1	1	-	9	14	13	16
Washington, Univ. of	9	1	-	2	-	1	1	7	1	22	20	18	5
Wash. State Univ.	5	1	-	1	-	-	-	3	2	12	12	1	0
West Virginia Univ.	1	1	-	-	-	-	-	4	-	6	5	2	7
Wisconsin, Univ. of	2	-	-	3	-	1	1	1	-	8	8	10	16
Wyoming, Univ. of	3	1	-	1	-	-	-	-	-	5	6	6	3
Totals	179	70	2	60	29	13	18	84	59	507	521	366	290





